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FIELD FORTIFICATION KIT

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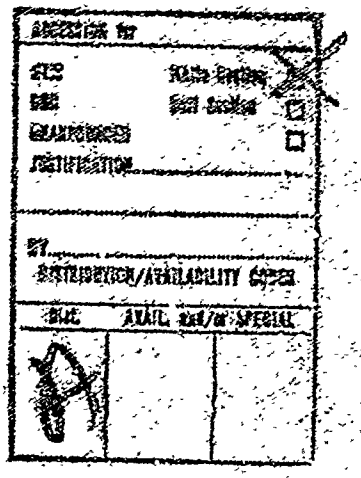
March 1974



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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report describes the development and feasibility test of a universally adaptable modular Field Fortification Kit System which appears to offer, when fully developed, a solution to most of the Army's needs for forward area bunkers and revetments. The Field Fortification Kit, when used in multiple kit quantities, provides a family of standardized bunker and revetment structures. A kit is essentially an assortment of corrugated aluminum panels of various lengths with a specified number of galvanized

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wire rope cables. The wire rope cables are used to assemble the panels into double-wall enclosures (panel bays) in making bunkers and/or revetments. The panel bays, connected in the desired bunker floor plan or revetment wall configuration, are filled with dirt or sand. To make a bunker, roof sheet panels are placed to span the earth filled walls, and an appropriate thickness of sandbags placed thereon. The Field Fortification Kit System was feasibility-tested at Aberdeen Proving Ground. It was found to be feasible and practical, and to provide protection against 81mm mortar fire. This task Final Report concludes that the Field Fortification Kit System is suitable for further development into hardware for troop use.

PREFACE

Although the Army uses bunkers and revetments extensively, there are no materials available within the supply system which are specifically designated for use in building bunkers or revetments. Generally speaking, the Army's field fortifications (bunkers and revetments) are constructed from expedient materials. The expedient materials are the so called "available materials", i.e., lumber of various sizes and grades, pierced steel planking, steel and aluminum culvert sections, and empty 55 gallon fuel drums. In many cases, however, the forward based troops do not have even the expedient materials.

There are two very serious problems inherent in the field expedient method of building bunkers and revetments. First of all, as mentioned above, such materials are not always so readily available. Secondly, and more serious, use of the expedient methods results in a multiplicity of designs and structural configurations. Many, if not most, of them are configured without the benefit of engineering considerations, are seriously deficient in structural adequacy, and often give only the illusion of protection.

The US Army Land Warfare Laboratory has developed the concept of a field fortification kit system which appears to offer a solution to most of the Army's needs for forward area bunkers and revetments. The concept, which is described in this report, consists of Type A and Type B Field Fortification Kits. Type A Kits are intented principally for use in making low-wall (57" high) revetments, though they can be used to make temporary bunkers. Type B Kits are intented primarily for bunkers, but they are equally useful in making bunkers and high-wall (6 feet high) revetments. The concept was feasibility-tested at Aberdeen Proving Ground, Maryland, including a very brief mortar (81mm) firing test program to establish structural integrity of the concept. The tests were conducted for LWL by USATECOM.[1] Though the concept in general was found to be feasible, practical and structurally sound, a full fledged development-engineering program would be required before prototype field fortification kits can be fully evaluated by tactical troops in a hostile environment.

The Modern Army Selected Systems for Test, Evaluation and Review (MASSTER) organization at Fort Hood, Texas is currently evaluating several currently available items of field fortification equipment. Their objective is to evaluate requirements, designs, and applications of field fortifications for a mid-intensity environment; and to determine needed improvements. One of the LWL Field Fortification Kits was sent to MASSTER for evaluation as a helicopter revetment for the UH-1. It was a Type A Kit intented primarily for use in making revetments, though it was envisioned that MASSTER would evaluate it both ways--first to make a revetment, and then to make a

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[1]TECOM Project No. 7-EG-275-000-001, Report No. APG-MT-4396, dated January 1974, Feasibility Test of Field Fortification Kit, Final Report Letter.

temporary bunker. Instead, however, it is being evaluated only in the bunker configuration. Furthermore, in the current MASSTER evaluation, the LWL Field Fortification is the only "above ground" bunker being evaluated by MASSTER although, like the other items being tested, it could be dug in. The MASSTER report on their overall field fortifications evaluation is expected to be available in July 1974.

It is believed that this report, which describes the LWL Field Fortification Kit development, can provide a good "starting point" for a successful program to develop field fortifications equipment suitable for most of the Army's needs.

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INTRODUCTION

This report describes and provides a record of the development and Feasibility Test of a Field Fortification Kit concept. The kits, when used in multiple quantities, provide a family of standard bunker and revetment structures.

The principal objective of the Field Fortification Kit Project was to devise and develop a standard set of materials and field installation methods which would be equally adaptable to any of the Army's forward area field fortifications requirements; i.e., helicopter revetments, barracks building revetments, personnel bunkers at the ends of barracks buildings, guard positions on encampment perimeter lines, living/fighting bunkers at artillery fire bases, command post facilities of company and battalion level size, and many other protective structures.

Two types of Field Fortification Kits were developed. The two types are referred to in the report as Type A and Type B. Type A Field Fortification Kits are intended primarily for making low-wall (57" high) revetments, though they can be used for making bunkers. Type B Field Fortification Kits are intented primarily for making bunkers; but they are equally adaptable for use in making high-wall (72" high) revetments.

Feasibility and Developmental Tests were conducted to establish the structural soundness of the concept and to develop suitable construction and assembly methods. During the tests a considerable amount of experimentation was conducted with various fabrication techniques and assembly methods. From this experimentation, the optimum procedures were determined and a preliminary Instruction Manual prepared. The Instruction Manual is included in this report as the Appendix.

The plan of the report is to present a description of the Field Fortification Kit System and its design parameters, and to give a summary of the Feasibility Test results. In describing the kit system, extensive references are made to the Appendix.

DESCRIPTION AND DATA

Type A Field Fortification Kit

The Type A Field Fortification Kit, shown in Figure 1, is essentially an assortment of 57.5" high corrugated aluminum panels of various lengths and a specified number of 23-foot long galvanized wire rope cables. A complete list of the materials which comprise one Type A Field Fortification Kit is given in Table 2-1 of the Appendix (Instruction Manual for the Field Fortification Kit System).

The principal use of the Type A Field Fortification Kit is to make revetments around UH-1 helicopter positions, barrack buildings, and other applications which need low wall revetment protection. A typical helicopter revetment is shown on LWL Drawing 050099700, Appendix A-1 to the Instruction Manual. The helicopter revetment requires use of one Field Fortification Kit. A typical barracks building revetment is shown on LWL Drawing 050099300, Appendix A-2 to the Instruction Manual. The barracks building revetment, which includes a personnel bunker at each end of the barracks building, requires three Field Fortification Kits, i.e., three of the basic modular quantities of material listed in Table 2-1 of the Instruction Manual.

Though the Type A Field Fortification Kits are intended primarily for making revetments, they can also be used to make temporary bunkers. A typical Type A temporary living/fighting bunker is shown on LWL Drawing 050099100, Appendix A-3 to the Instruction Manual. Construction of the living/fighting bunker requires the use of one Field Fortification Kit. A typical Type A temporary command post for a battalion is shown on LWL Drawing 050099500, Appendix A-4 to the Instruction Manual. The Command Post facility requires the use of three Field Fortification Kits.

To make a bunker or revetment, the corrugated aluminum panels are assembled to form double walled enclosures referred to as wall panel bays. The panels are connected to each other in rectangular box configuration by interlacing the abutting panels with the wire rope cables. After the panel bays are assembled into the desired bunker floor plan or straight wall revetment configuration they are filled with dirt or sand. In constructing a bunker, corrugated aluminum roof sheets are placed to span the earth filled walls, and an appropriate thickness of sandbags is placed on top of the roof sheets. A typical Type A bunker is shown in Figure 2, and a typical length of Type A revetment in Figure 3. Complete assembly details are given in the Instruction Manual for the Field Fortification Kit System, the Appendix.

Type B Field Fortification Kit

The Type B Field Fortification Kit differs from the Type A Kit only in panel height and connector cable length; some of the Type B cables are 25 feet long and some are 30 feet long, and some of the aluminum panels are 75" high while some are 57" high. A list of the component materials which comprise the Type B Kit are given in Table 2-2 of the Instruction Manual. Detailed

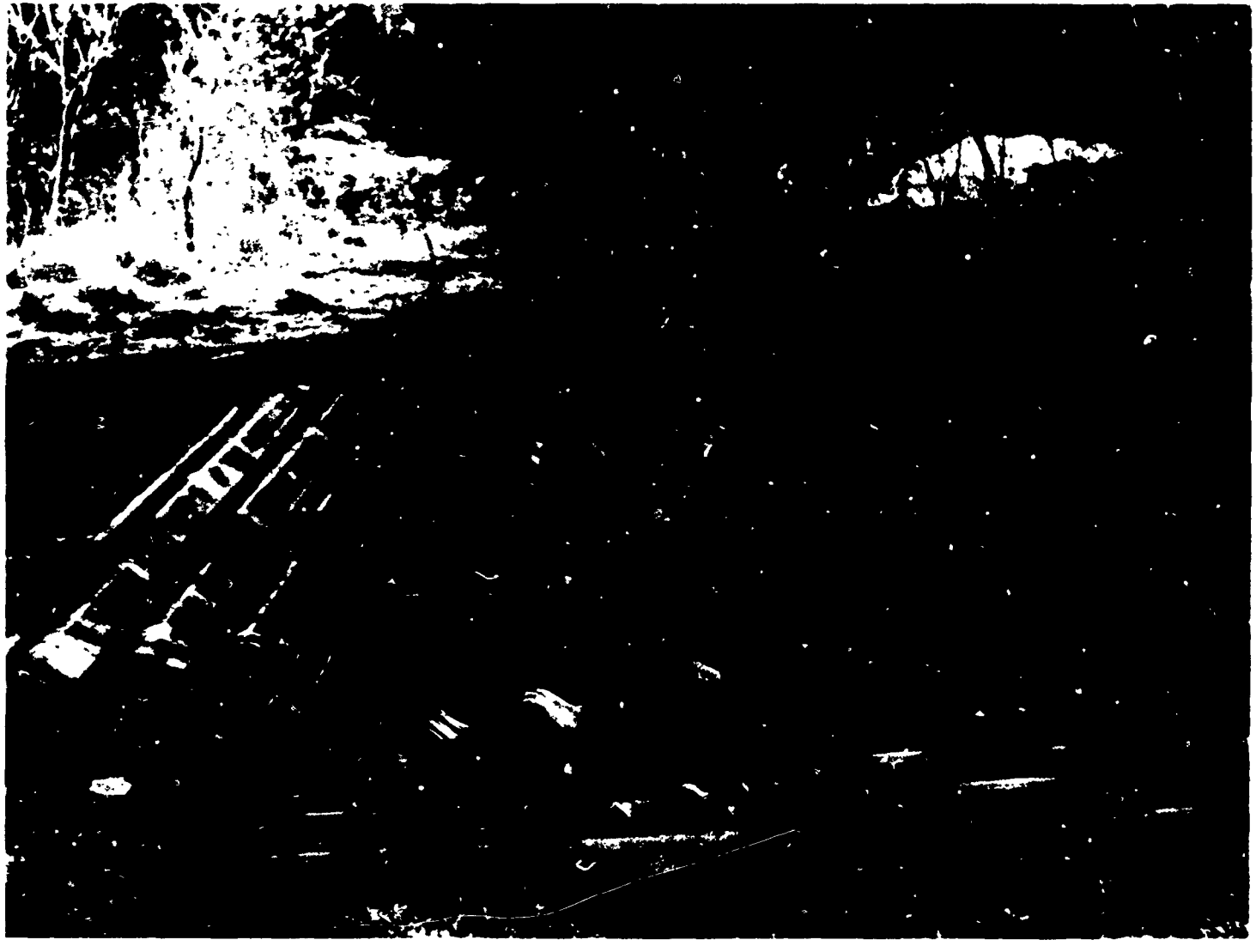

Figure 1. A Typical Type A Field Fortification Kit Suitable for Making One Type A Revetment for the UH-1 Helicopter, or One Type A Living/Fighting Bunker

Figure 2. A Typical Type A Bunker

Figure 3. A Short Section of a Typical Type A Revetment

assembly instructions for building Type B bunkers and revetments are given in the Instruction Manual. The assembly drawings for a typical Type B living/fighting bunker, a typical command post facility, and a typical barracks revetment are given as Appendixes B-1 thru B-3 to the Instruction Manual.

APPLICATION AND DESIGN PARAMETERS

Structural Characteristics

The structural characteristics and construction techniques inherent in the LWL Field Fortification Kit concept differ from conventional methods of construction. The principal differences are that (1) the roof is not physically tied to the walls, (2) the walls do not require prepared foundations, and (3) the sandbagged roof exerts inordinately high loads on the walls. These differences require that certain safety procedures be followed; provided that they are followed, bunkers made from the Field Fortification Kits can be safely constructed and used. The applicable safety procedures are set forth in the Appendix, Instruction Manual for the Field Fortification Kit System.

Concept of Use, Types A and B Kits

Type A Field Fortification Kits are intended primarily for making low-wall revetments particularly for UH-1, AH-1 and OH-type helicopters which must be capable of flying in and out of their revetments. Type B Field Fortification Kits are intended primarily for making bunkers; they are equally suitable for revetments except for UH-1, AH-1 and OH-type helicopters.

Type A Field Fortification Kits may be used to construct bunkers, if Type B Kits are not available, by extending the wall height approximately 18 inches through the use of sandbag parapets. When Type A bunkers are constructed, the sandbags must be carefully placed so as to provide a uniformly solid and stable bearing wall; and the roof and parapet wall extensions must be disassembled and new sandbags emplaced at least every four months to insure that the roof is not being supported by deteriorating sandbags.

Configuration and General Arrangement

Some typical field fortification sample layouts are detailed in the Instruction Manual, the Appendix to this report. With use and as new applications appeared the sample layouts could include a large number (perhaps hundreds) of typical bunker floor plan arrangements, bunker groupings for Tactical Operations Center facilities, and many other field fortification layouts. The Field Fortification Kit embodies all of the advantages of the traditional "erector set" concept. It is intended that the potential user be able to "put together" any configuration he needs without finding in the Instruction Manual a typical design to his liking. When making his own layout, however, the user must observe the following considerations:

a. Limit the maximum roof span to 82 inches. The inside clear span between load bearing walls must not exceed 82 inches, which is the length of one "8N" panel as listed in Tables 2-1 and 2-2 of the Appendix. This

limitation is necessary in order to assure adequate beam strength in the roof sheets. The roof sheets are long enough to extend completely across and cover both load bearing walls, provided that the walls are not further apart than 82". When the roof sheets are accurately emplaced the roof loading will be uniformly distributed onto the sandbag capped walls.

b. Limit the width of openings in load bearing walls to 36 inches. Each opening in a bearing wall is bridged by a lintel on top of the sandbag capped bearing wall. The lintel transmits the load from the bridged part of the roof into a short length of the bearing wall at each side of window or door opening. This in effect overloads the bearing wall on each side of the wall opening, the amount of overload increasing as the width of wall opening increases. It is therefore important that the bunker layout be planned so that the wall openings for window and passage ways are kept to the minimum acceptable width.

c. Reinforce the terminal ends of all load bearing walls. In order to compensate for the bearing wall overloads at passage ways, as described in the above paragraph, it is necessary to provide lateral support to the walls at the passage ways. This can be accomplished by building a right angle turn to the wall at each side of the passage way. This in effect provides a short hallway or corridor at each bunker entrance.

d. Provide lateral support to each end of each panel bay. The bunkers and revetments should be built on fairly level and uniformly textured terrain so that the wall footings do not sink significantly more under one side of the wall than under the other, and so that the footing under one wall does not sink significantly more than the footing under the opposite wall. To provide positive assurance of wall stability however, and to compensate for those situations where the terrain conditions cannot be controlled, it is necessary that a right angle abutting panel bay wall section be built into the bunker wall at each end of each panel bay wall section. For revetments, it is suggested that the lateral support be provided at each two to three panel bay series, depending upon the terrain conditions. The typical configurations shown in the Appendix include these lateral support features.

FEASIBILITY TESTS

Test Objectives

The principal objectives of the tests were to develop a practical method of fastening the corrugated aluminum panels to each other; to determine by destructive testing if the Field Fortification Kit concept is structurally sound; and, to develop suitable assembly and disassembly procedures for use in preparation of an instruction manual for the Field Fortification Kit System.

Test Procedures

Several methods of fastening the panels were investigated. The two most promising were the connector-post system as shown in Figures 4 and 5, and the wire rope cable system shown in Figures 3-2 thru 3-5 of the Appendix. The wire rope cable system was selected as the best approach.

Seven (7) test-bed field fortification arrangements were assembled and disassembled. Three (3) of them were subjected to 81mm mortar detonation tests; one Type A bunker as shown in Figures 6 and 7, one Type A revetment as shown in Figure 3, and one Type B bunker as shown in Figure 8. A total of ten (10) 81mm mortar rounds were detonated against the three test-bed field fortification structures. The firing test results are recorded in the TECOM Report (see Footnote 1 on page vi).

Summary of the Firing Test Results

Type B Bunker. Four mortar rounds were detonated against the Type B bunker. Figure 8 is a photograph showing the Type B bunker after completion of the four shots. Figure 9 shows the interior of the bunker prior to the test firing. Figure 10 shows the positioning of Round 1 on the roof; it was placed at 60^{o} from horizontal, and located near mid-span of the roof. Except for the torn sandbags, as shown in Figure 11, no damage was incurred. Figure 12 shows positioning of Round 2, located directly over the sidewall; and Figure 13 shows the slight interior damage (sidewall indentation) resulting from the mortar blast. Figure 14 shows the damage to the sandbags due to Round 2. Figures 15 and 16 show the results of Round 3; except for the torn sandbags, no damage occured. Figure 17 shows positioning of the 81mm mortar Round 4 for direct hit firing against the sidewall; Figure 18 shows the damage to the exterior of the wall, and Figure 19 shows the interior view. The direct hit did not do damage to the inside of the bunker. Figure 20 shows an interior view after completion of the firing tests, to be compared with Figure 9 which shows a comparable view before the firing tests. Except for the torn exterior, sustained during the direct hit against the sidewall, the damage due to the test firing was insignificant. There was no indication of wall instability nor wall movement.

Type A Bunker. Four 81mm mortar rounds were detonated against the Type A bunker in a manner similar to that used against the Type B bunker described

Figure 4. A Potential Method of Connecting the Fortification Wall Panels - The Connector-Post Method

Figure 5. A Test-Bed Revetment Set-Up Which Utilizes the Potential Connector-Post Method of Connecting Wall Panels

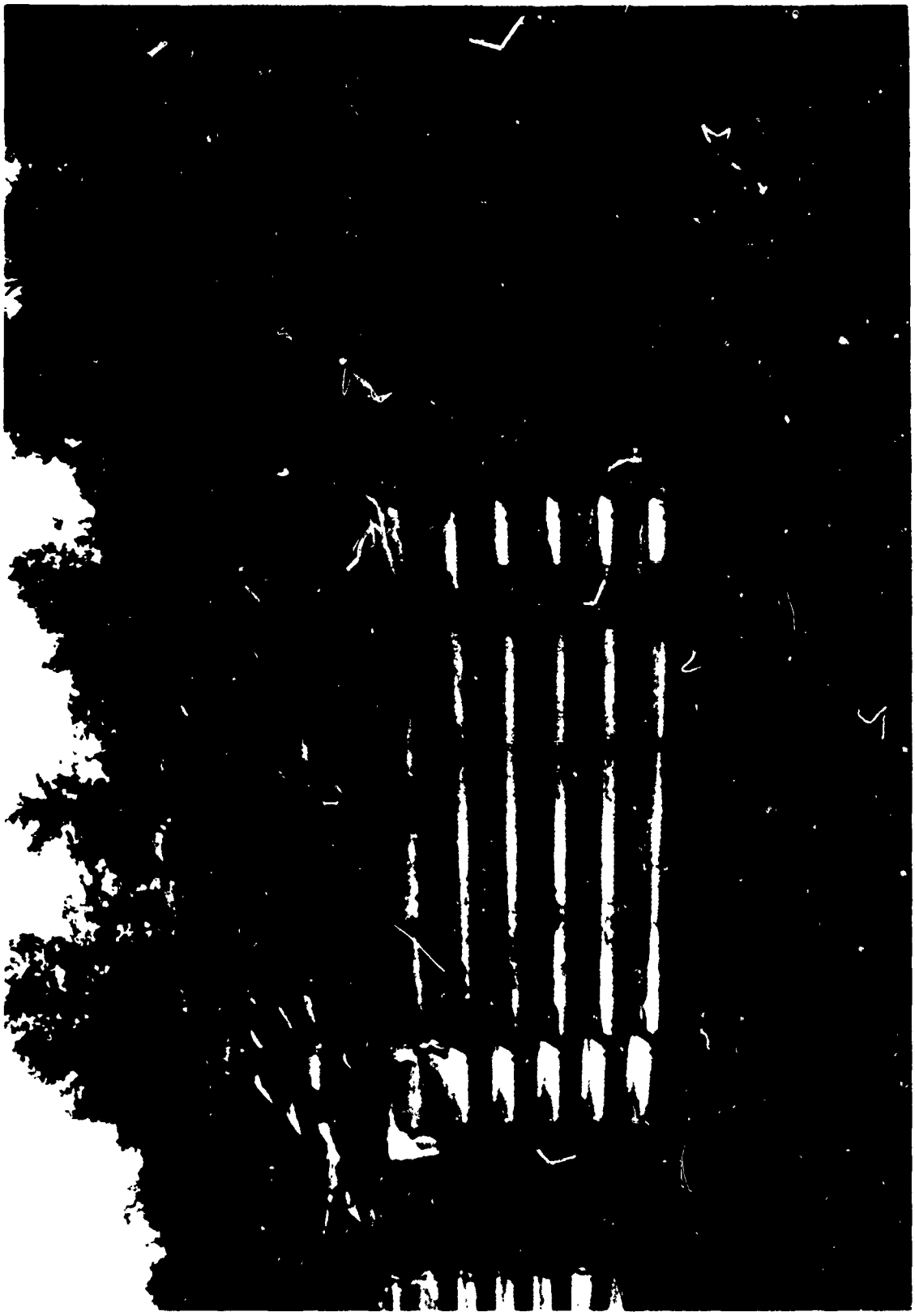

Figure 6. Type A Field Fortification Kit Bunker, Back Side View

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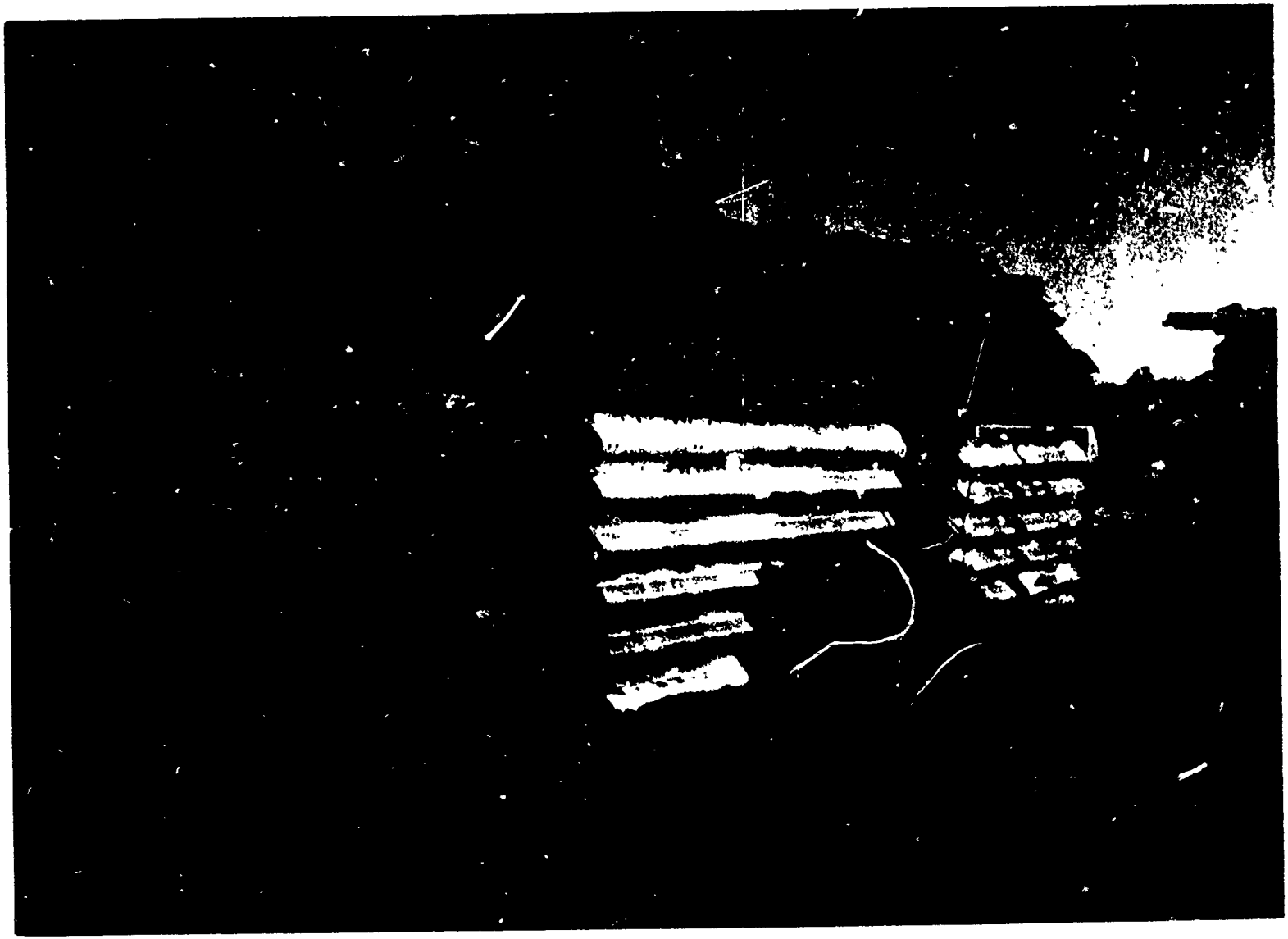

Figure 7. Type A Field Fortification Kit Bunker, Front Side View

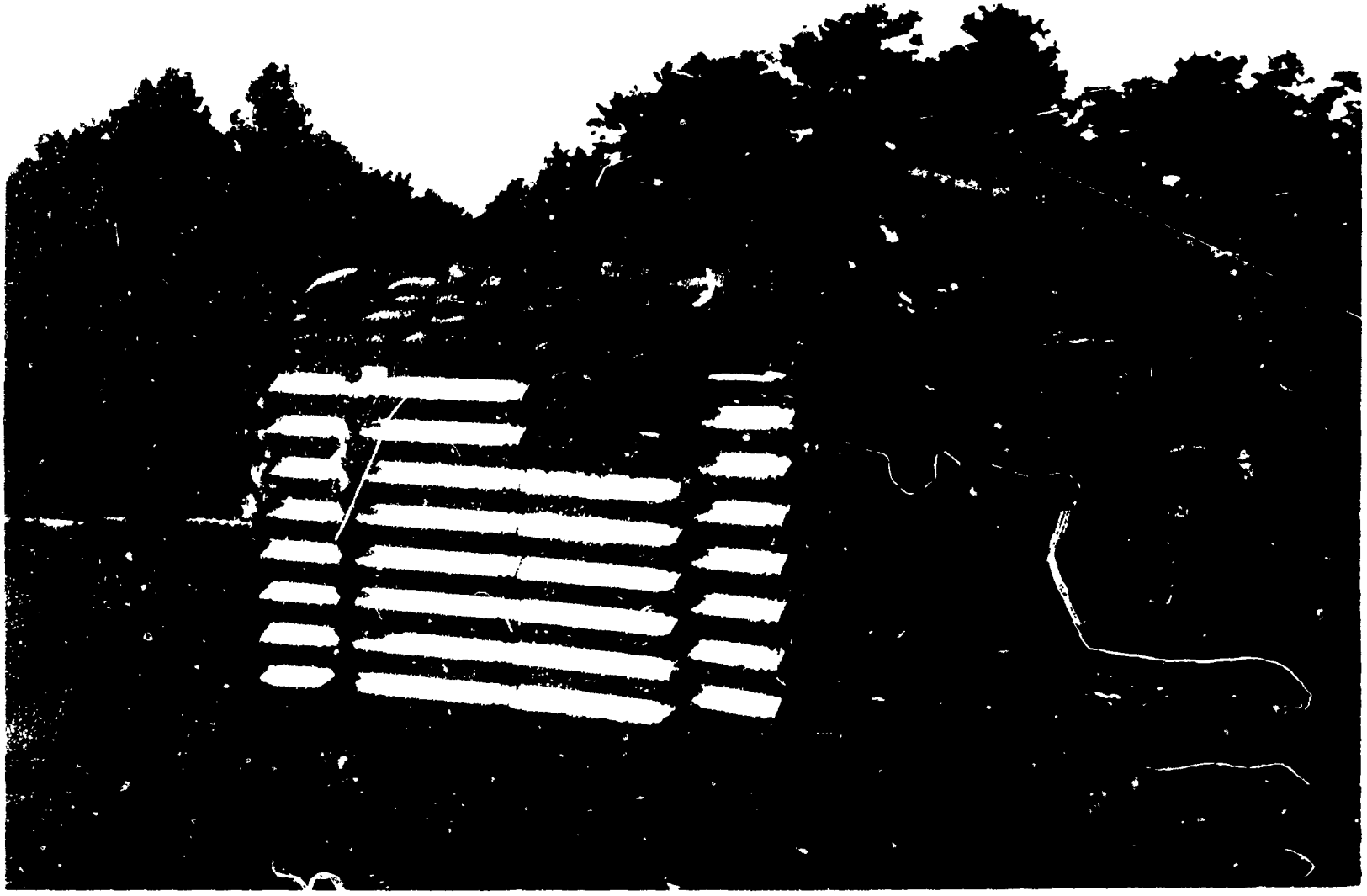

Figure 8. A Typical Type B Bunker, Shown After Completion of the Firing (81mm Mortar Tests)

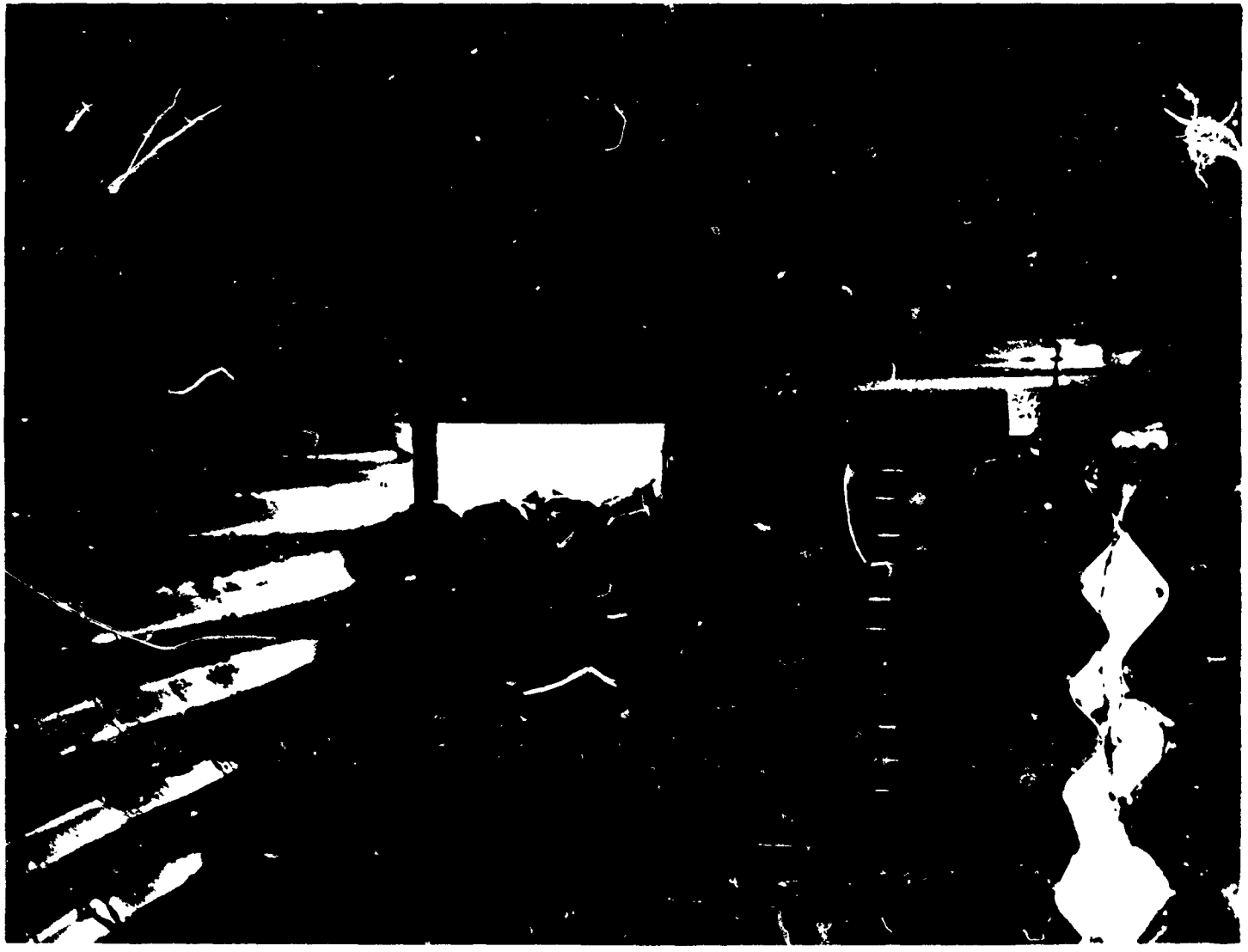

Figure 9. Interior View of the Type B Bunker Prior to the Test Firing

Figure 10. Location of Round No. 1 on the Type B Bunker

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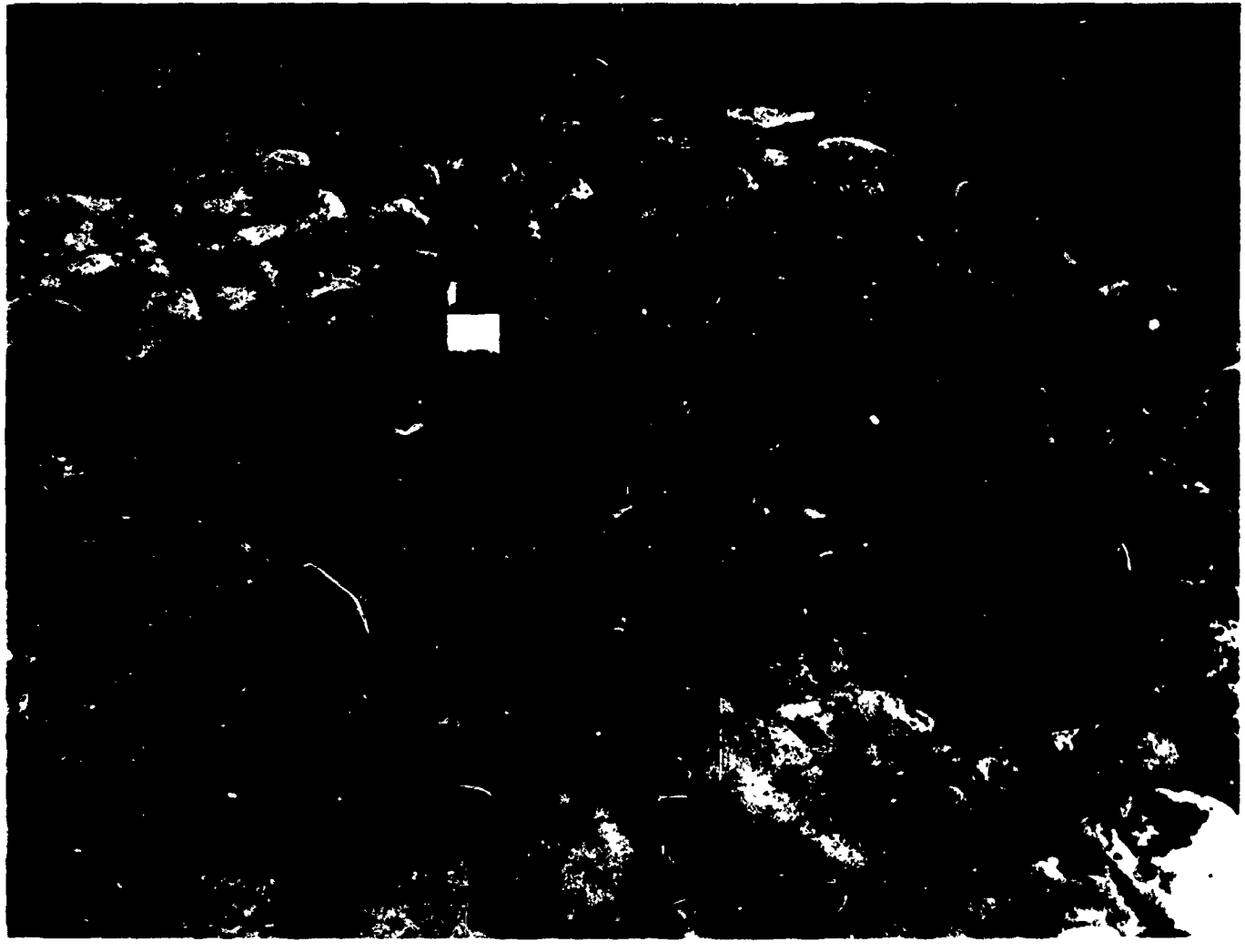

Figure 11. Results of the 81mm Mortar Blast on the Sandbagged Roof Top

Figure 12. The 81mm Mortar Round No. 2, Positioned on the Type B Bunker

Figure 13. Results of the 81mm Mortar Round No. 2. Detonated on the Roof of the Type B Bunker, Showing Slight Damage to the Interior

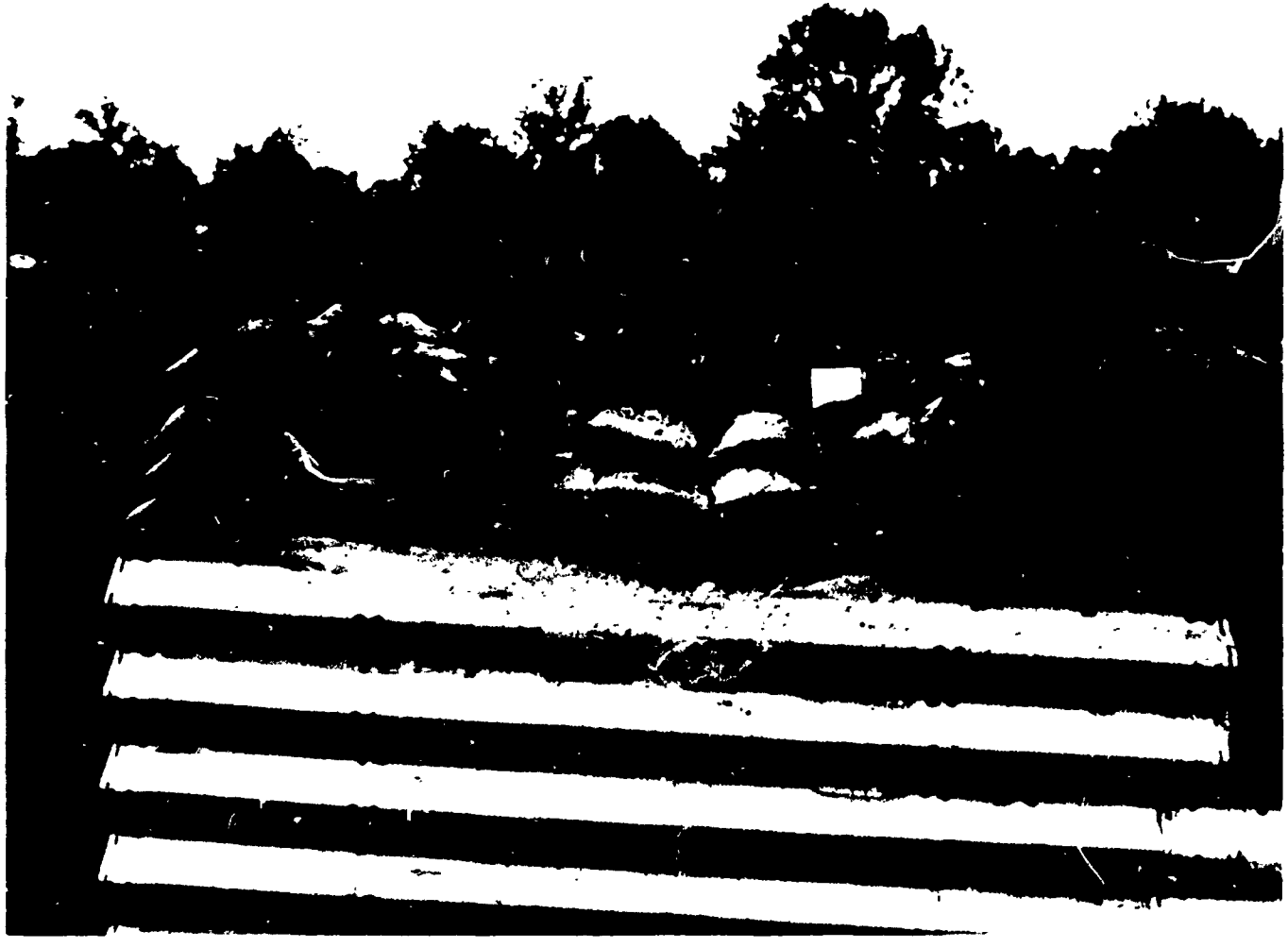

Figure 14. Exterior View of the Type B Bunker, Showing the Slight Damage to the Sandbags Due to the 81mm Mortar Round No. 2

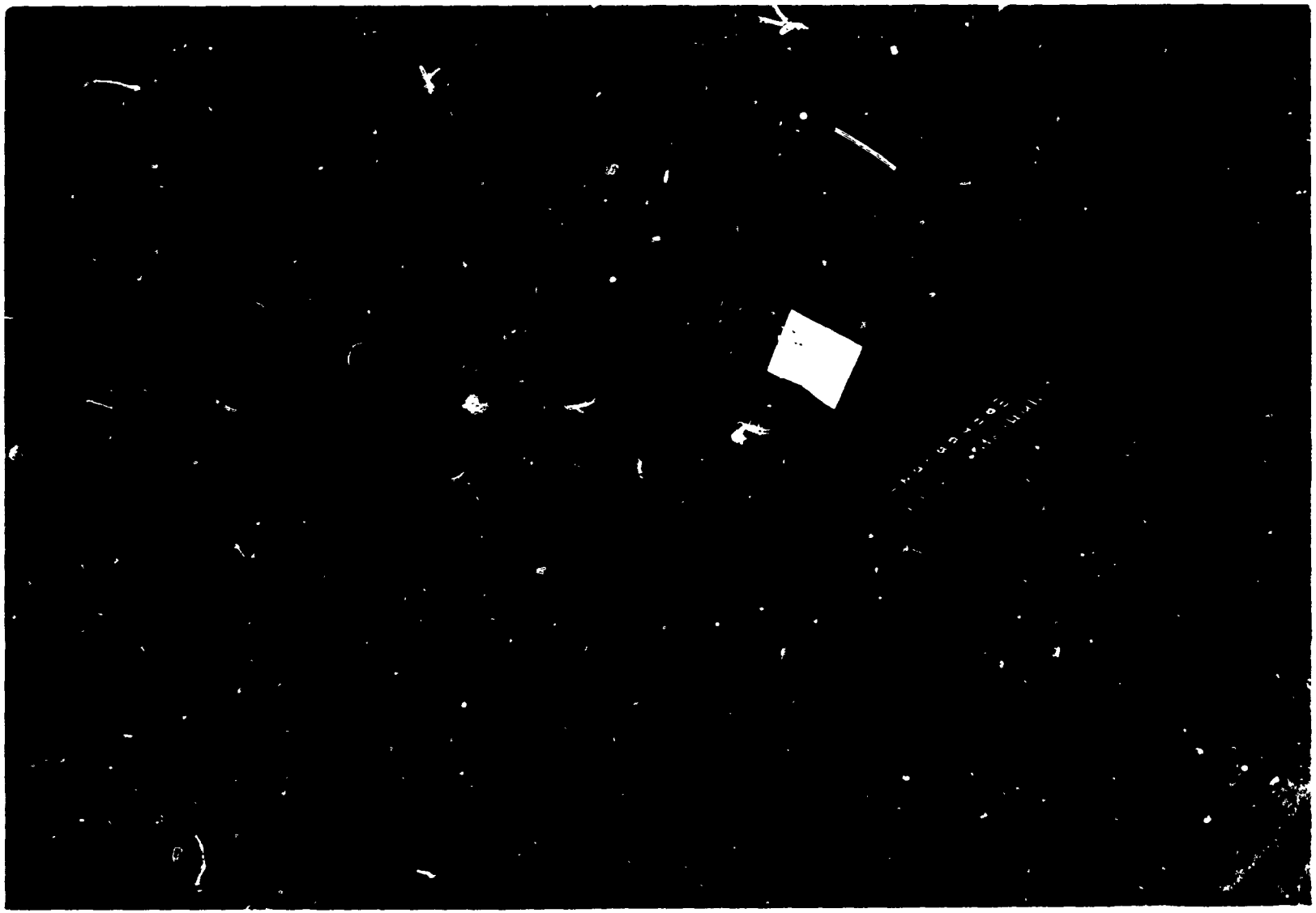

Figure 15. Round No. 3 Detonated on the Type B Bunker.

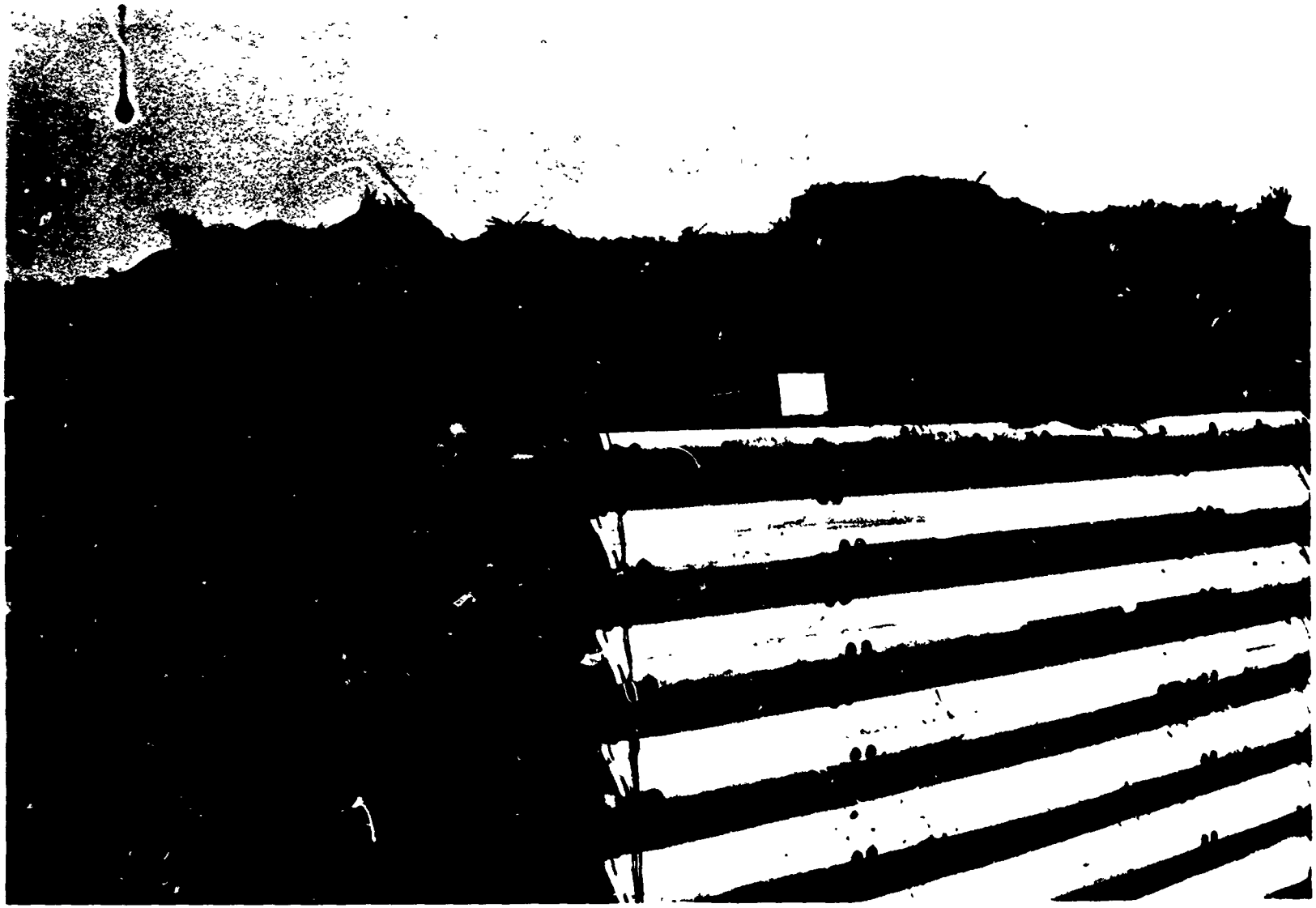

Figure 16. Results of Round No. 3 Detonated on the Type B Bunker

Figure 17. Positioning of Round No. 4 for Direct Hit Against the Type B Bunker Sidewall

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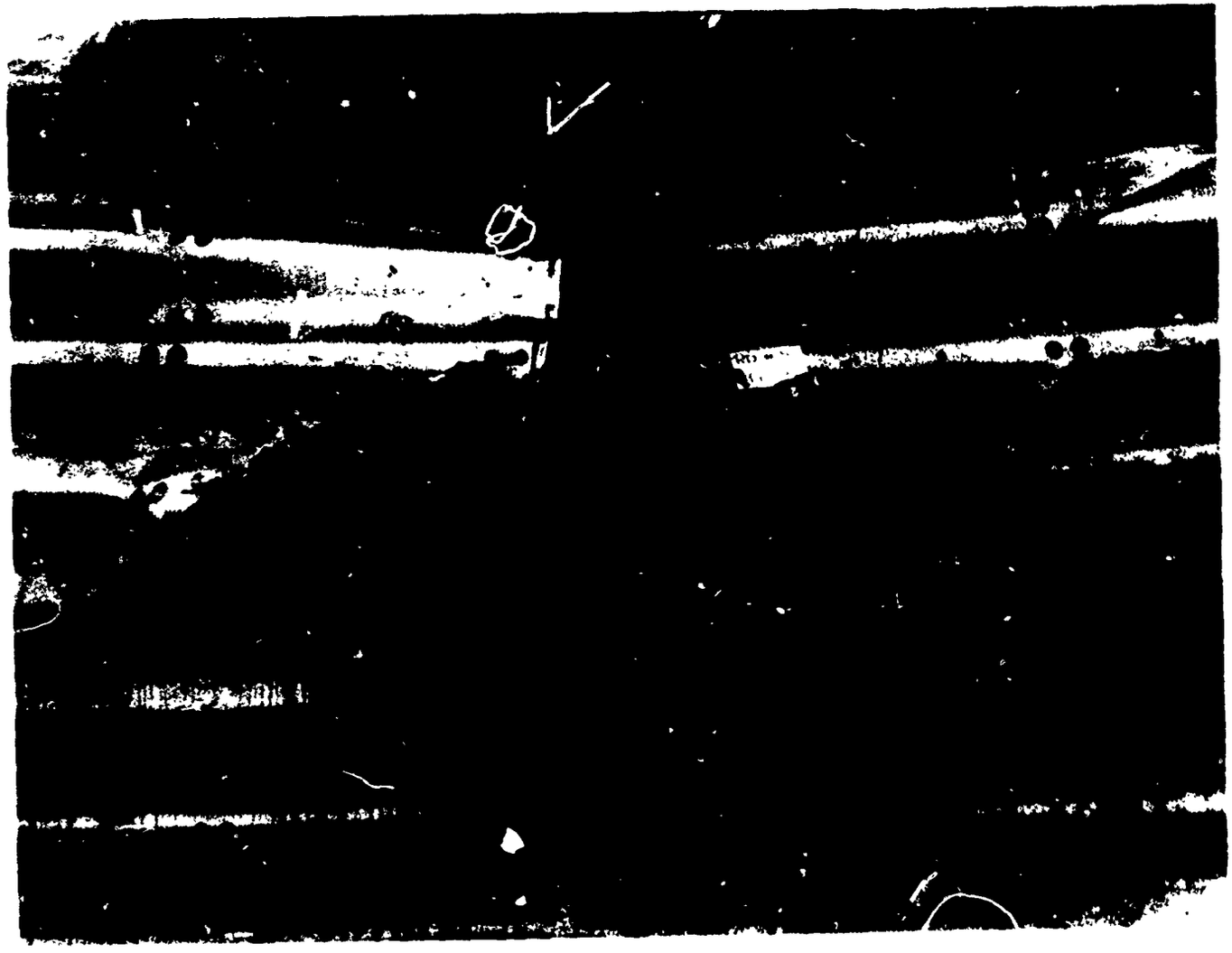

Figure 18. Damage to the Type B Bunker Sidewall Due to the Direct Hit by 81mm Mortar

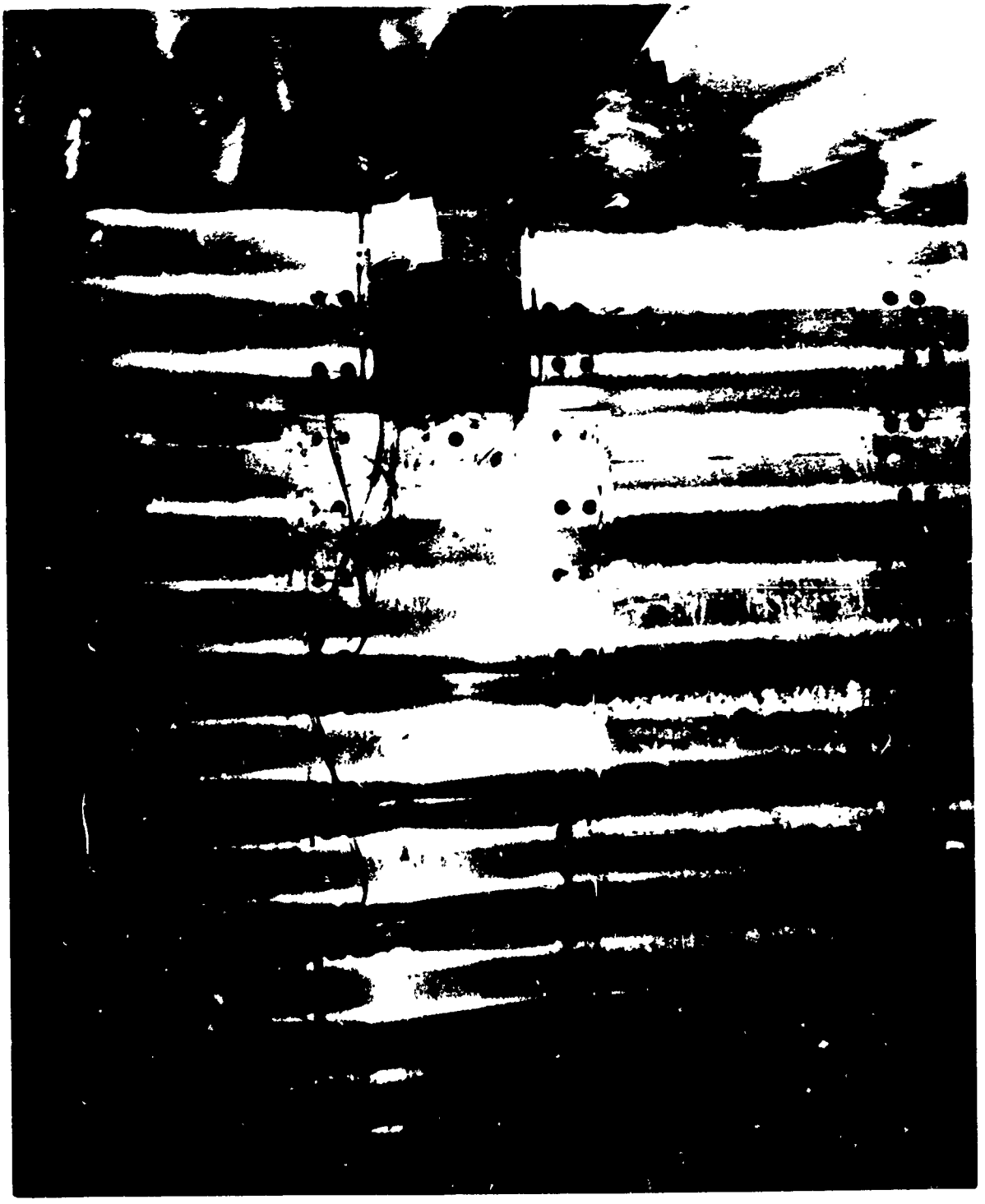

Figure 19. Interior View of the Type B Bunker Sidewall Showing That No Interior Damage Resulted From the Direct Hit by 81mm Mortar. There Were No Penetrations.

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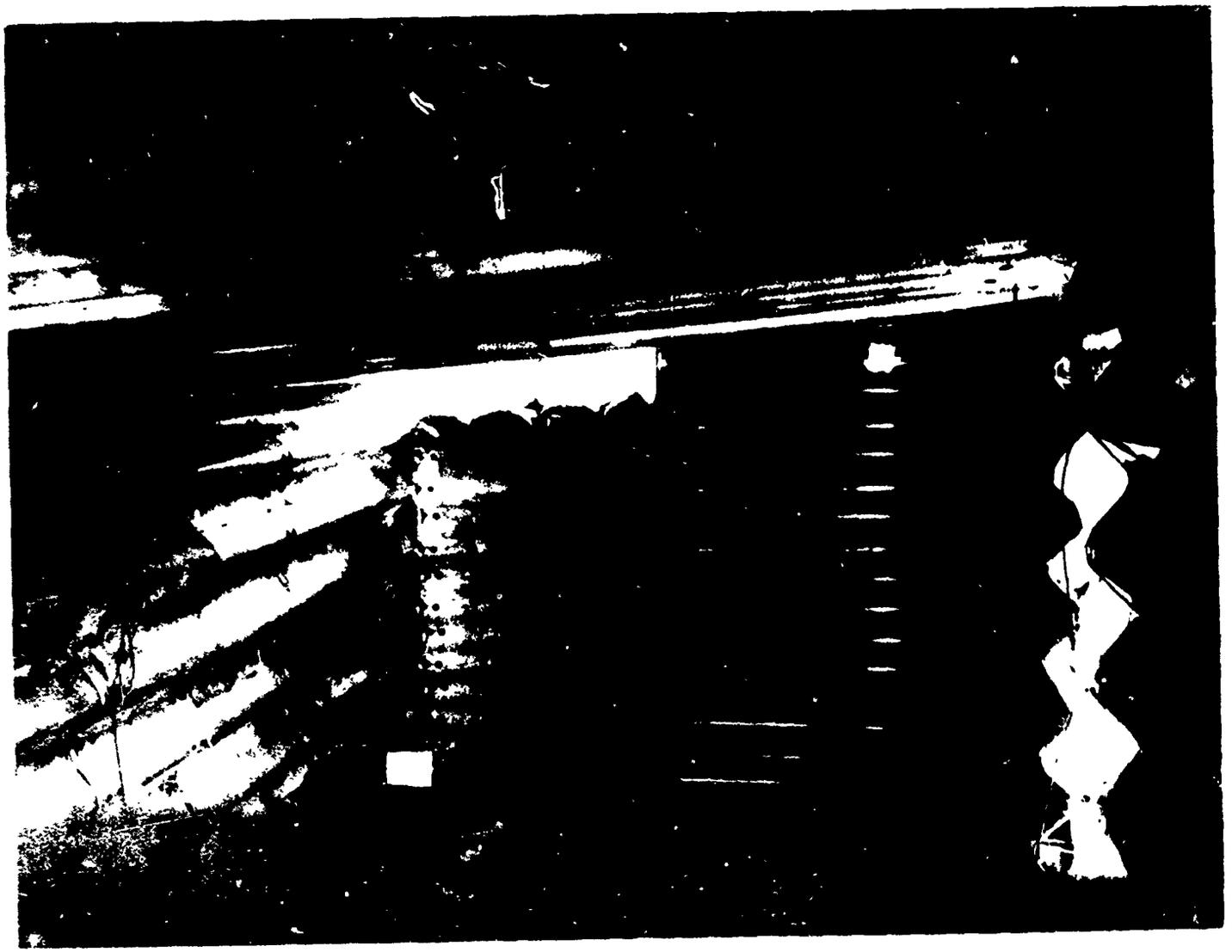

Figure 20. Interior View of the Type B Bunker After Completion of the Test Firing

above, except that no direct hit against the sidewall was made. Figures 21 thru 28 show the positioning and the results of each mortar round detonation. Figure 29 shows a view of the entryway after completion of the firing tests. The slight curvature of the wall at the non-supported-entryway illustrates the need for support of the terminal end of all bunker walls. (Refer to the preceding discussion under the heading Application and Design Parameters.)

Type A Revetment. Two mortar rounds were fired against the test-bed Type A revetment. Figures 30 thru 34 show the positioning and results of the 81mm mortar rounds detonated against the Type A revetment. The wall did not show evidence of instability or side movement.

Summary of Assembly and Disassembly Tests

Wall Panel Connections. Various wire rope lacing techniques were used in connecting the wall panels during the assembly operations. Although a "best" method was devised, and illustrated in the Instruction Manual (Appendix), it was found that any reasonable lacing method will work.

Assembly and Disassembly Procedures. Appropriate assembly and disassembly procedures were devised during the fabrication test operations. They are described in the Instruction Manual. To disassemble the fortification, the wire rope cables are cut with a cable cutter, beginning at the bottom and progressing to the top of each wall panel connection. Approximately 16 man minutes (2 men working 8 minutes) are required to assemble or disassemble one wall panel connection.

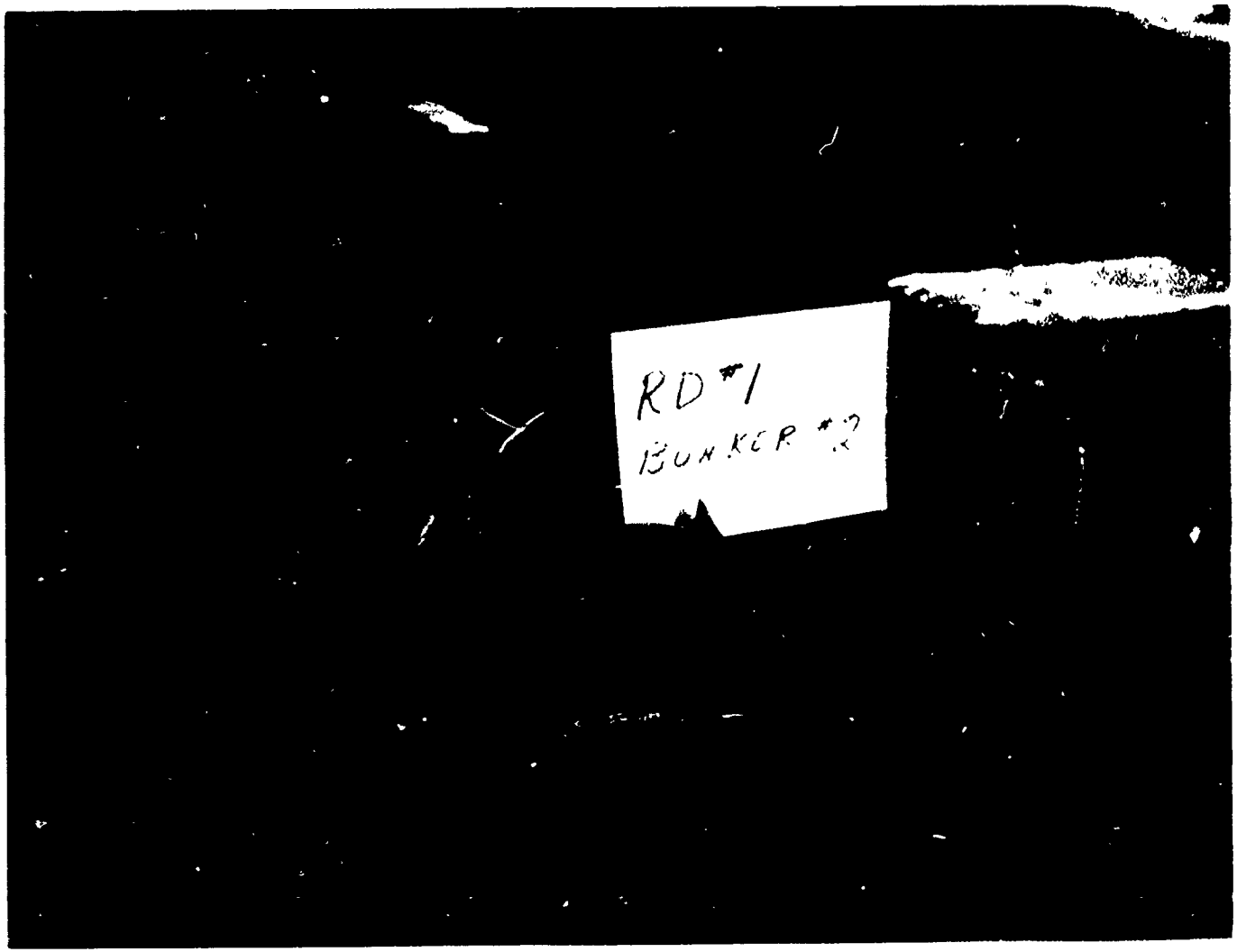

Figure 21. Positioning of an 81mm Mortar Round No. 1 Over the Sidewall of the Type A Bunker

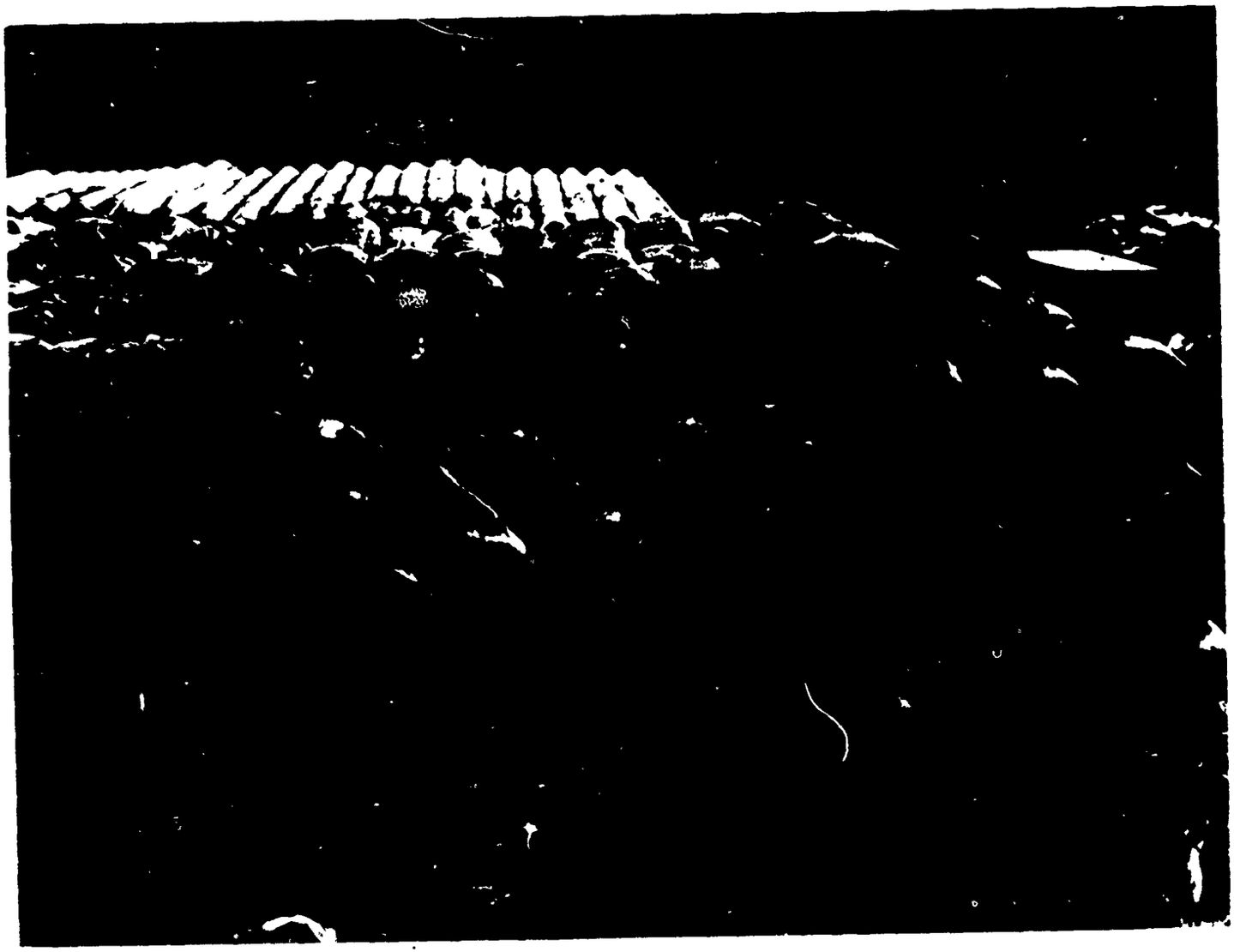

Figure 22. Results of Mortar Round No. 1 Detonated on the Type A Bunker

Figure 23. Positioning of 81mm Mortar Round No. 2 Against the Type A Bunker

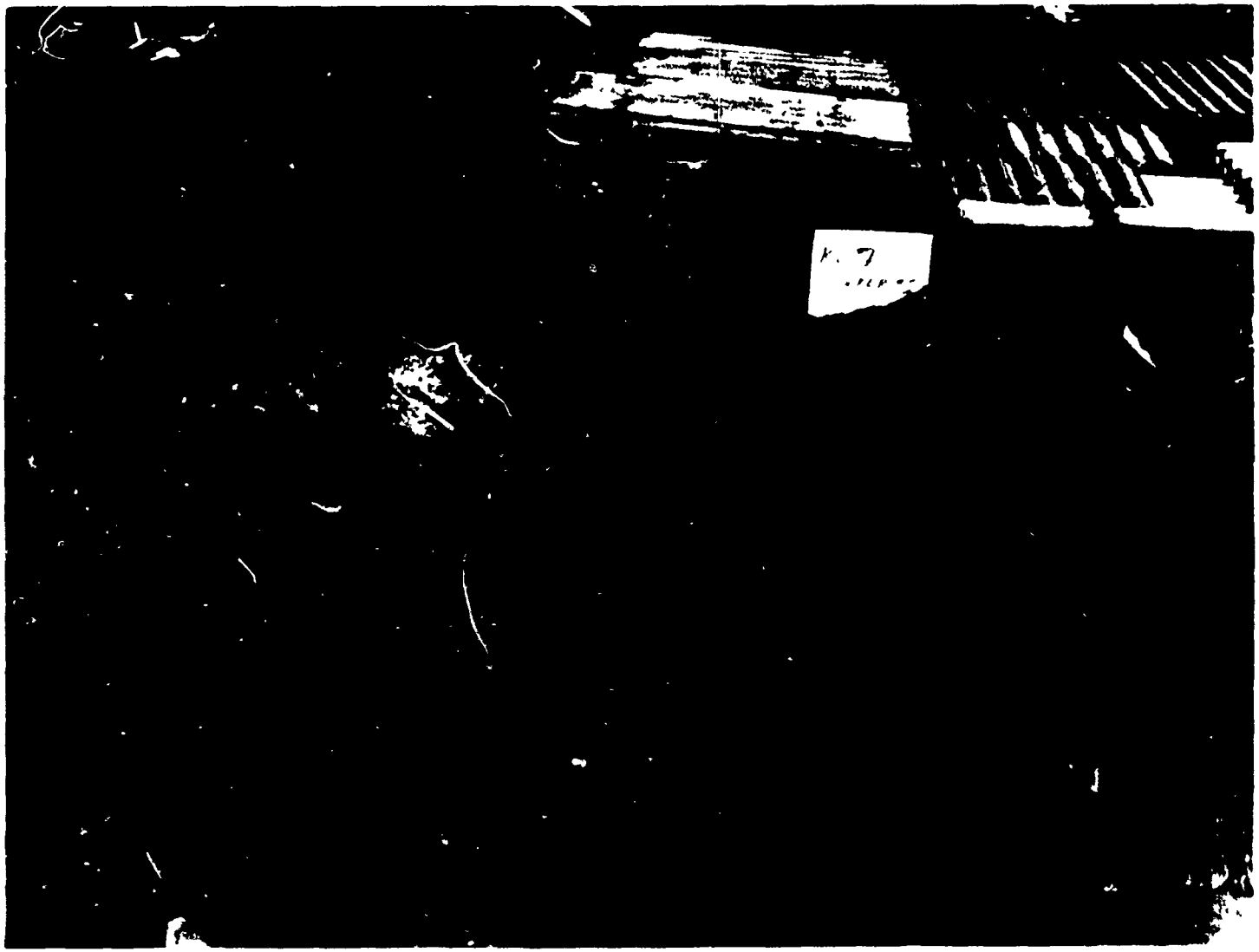

Figure 24. Results of Mortar Round No. 2 Detonated Against The Type A Bunker

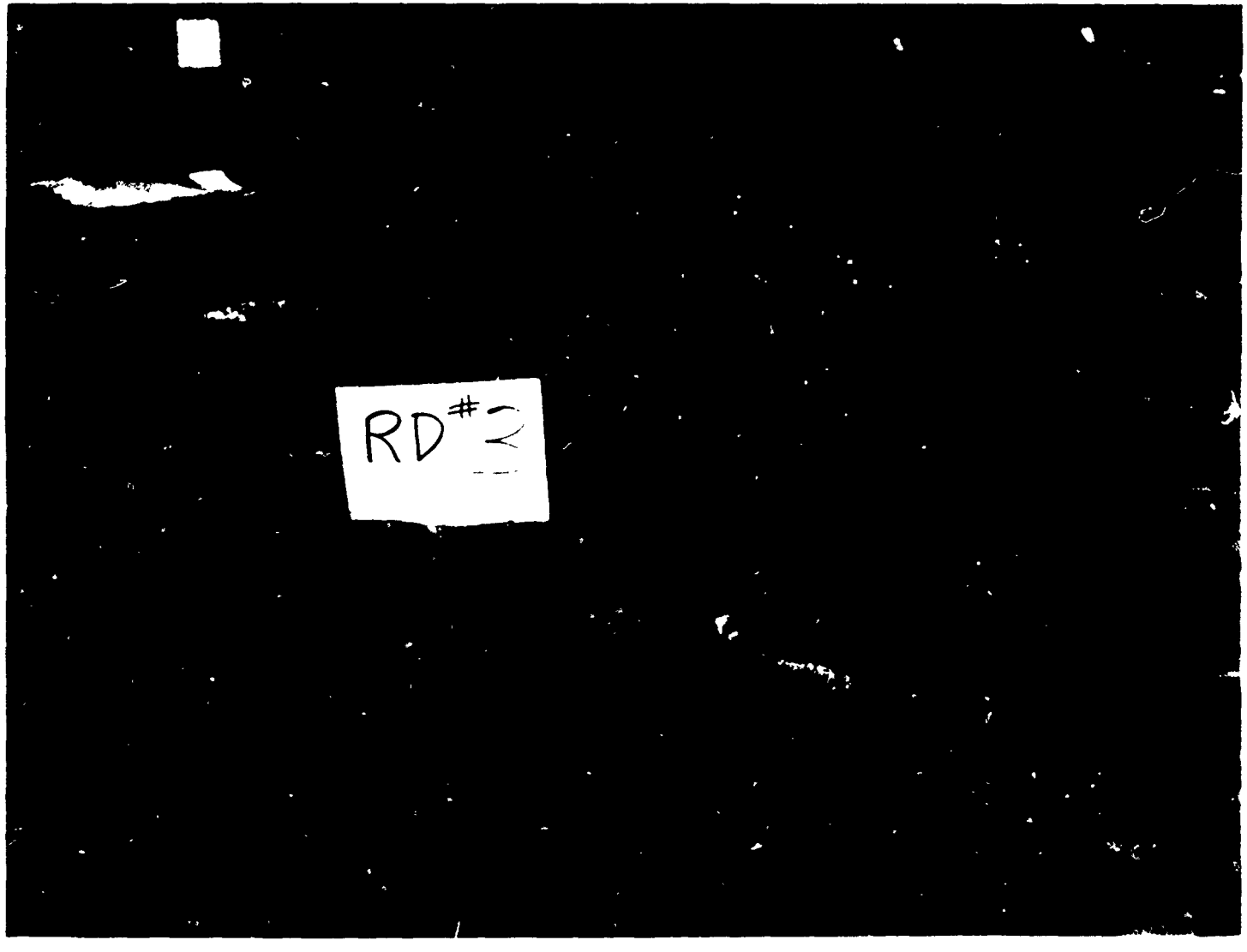

Figure 25. Positioning of 81mm Mortar Round No. 3 on the Type A Bunker

Figure 26. Results of Mortar Round No. 3 on the Type A Bunker

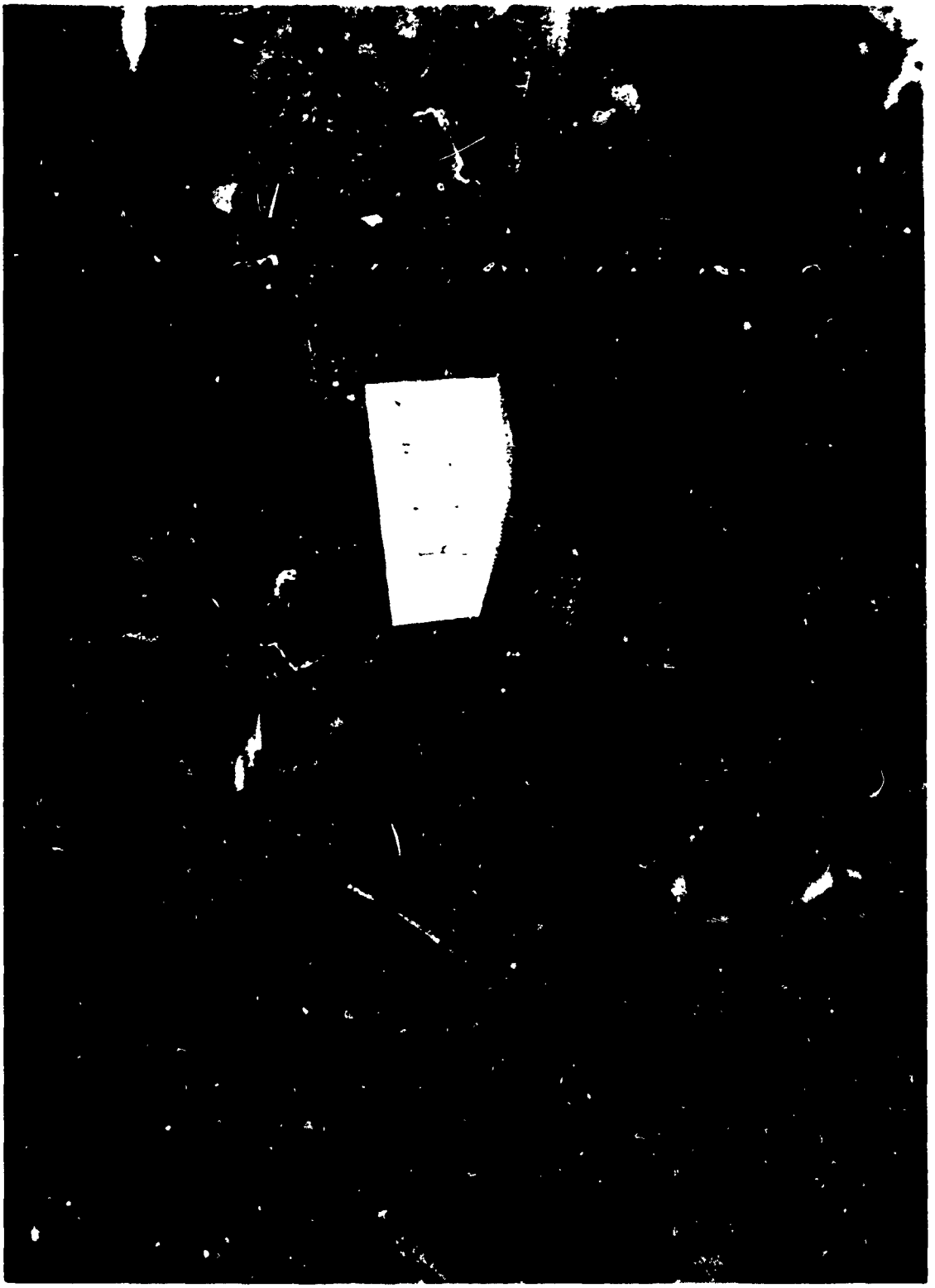

Figure 27. Positioning of 81mm Mortar Round No. 4 on the Type A Bunker

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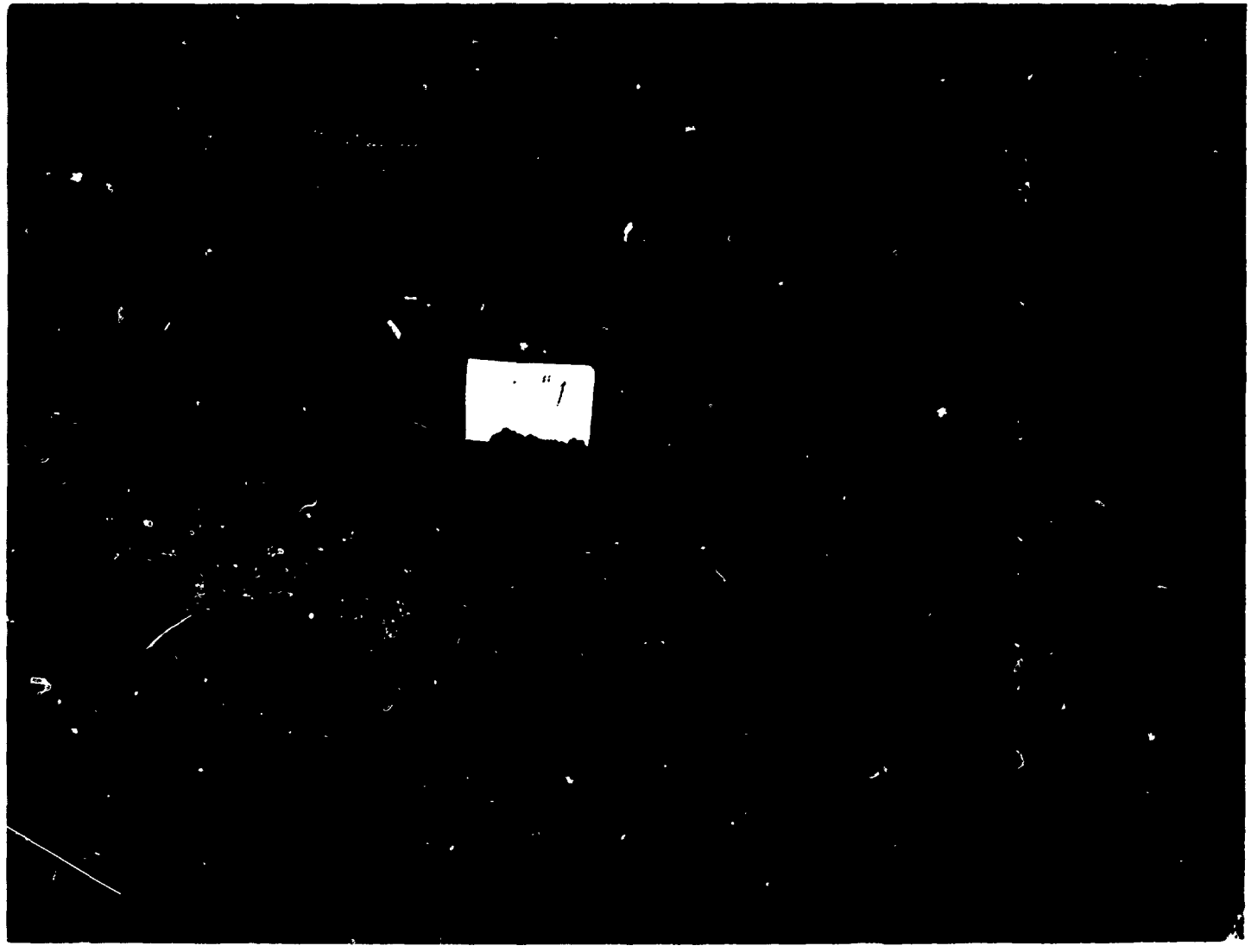

Figure 28. Results of Mortar Round No. 4 Detonated on the Type A Bunker

Figure 29. A View of the Type A Bunker After the Test Firing. Note the Slight "Bow" or Curvature of the Wall at the Non-Supported Entryway

Figure 30. Positioning of an 81mm Mortar Round for Detonation on the Type A Revetment

Figure 31. Results of the Mortar Round Detonated on Top of the Type A Revetment Wall, Top View

Figure 32. Results of the Mortar Round Detonated on Top of the Type A Revetment, Side View

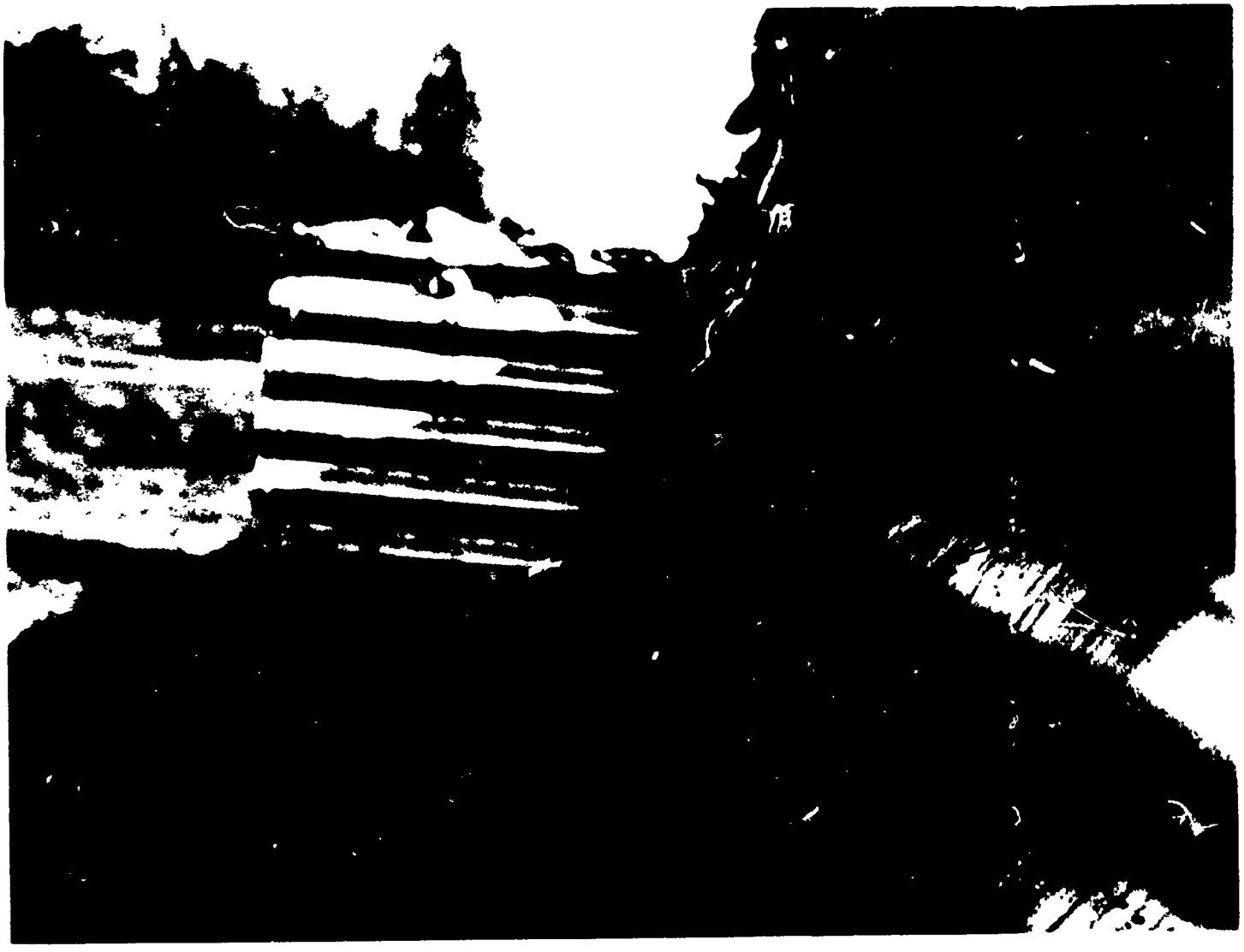

Figure 33. Positioning of an 81mm Mortar Round for Detonation Against the Sidewall of the Type A Revetment

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Figure 34. Results of the Mortar Round Detonation Against the Sidewall of the Type A Revetment

CONCLUSIONS

The Field Fortification Kit System provides troop units with a feasible and practical combination of material and techniques for erecting a variety of bunkers and revetments.

The bunkers and revetments made by use of the Field Fortification Kit System can provide adequate protection from 81mm mortar fire and small arms.

Additional developmental testing would be required to establish and demonstrate the ability of the structures to withstand 122mm rocket fire.

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APPENDIX

PRELIMINARY INSTRUCTION MANUAL FOR THE FIELD FORTIFICATION KIT SYSTEM

APPENDIX

PRELIMINARY

TECHNICAL MANUAL

INSTRUCTION MANUAL

FOR THE

FIELD FORTIFICATION KIT SYSTEM

LWL TASK 02-M-73

by

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Mobility Branch

January 1974

U.S. ARMY LAND WARFARE LABORATORY
ABERDEEN PROVING GROUND, MARYLAND 21005

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FIG. NO.

SAFETY SUMMARY

Safety precautions and procedures appear elsewhere in this Preliminary Instruction Manual. Those precautions and procedures must be understood and applied by potential users of the Field Fortification Kit; otherwise, use of the Field Fortification Kit system would be subjected to potentially unsafe conditions. Therefore, though they appear elsewhere in this manual, the following safety precautions are rephrased here below for emphasis:

HAND GLOVES MUST BE WORN WHILE WORKING WITH THE FIELD FORTIFICATION KIT PANELS. The panels have mill cut edges - the edges have not been rounded and ground smooth. These unfinished edges may cut and scratch the hands if gloves are not worn.

THE FIELD FORTIFICATION KIT MUST BE "PLANNED RIGHT" AND "PUT UP RIGHT", OTHERWISE IT WILL BE SUBJECT TO POTENTIALLY UNSAFE CONDITIONS. This is due in large part to the unusually high roof loads imposed by the sandbagged roof, to the fact that the roof is not physically tied to the walls, and to the fact that the loadbearing walls do not have "prepared" foundations. It is, therefore, especially important that the potential users maintain a firm awareness of the safety implications set forth in Chapter 3, and rigidly adhere to them.

CHAPTER 2

DESCRIPTION AND DATA

Section I. Type "A" Field Fortification Kit

2-1 Components, Type "A" Kit

The Type "A" Field Fortification Kit is, essentially, an assortment of 57 1/2" high corrugated aluminum panels and a specified number of 23-foot long galvanized wire rope segments. The assortment includes a sufficient quantity to erect a typical helicopter revetment for UH-1 series helicopters. The corrugated aluminum panels are a standard commercial product used in industrial applications, principally to make highway drainage culverts and marine bulkhead retaining walls. The wire rope segments, which serve to connect the aluminum panels to each other, are made from standard commercially available 7 x 19 galvanized steel wire rope of 3/16" diameter. A complete list of the components which make up the Type "A" Field Fortification Kit is given in Table 2-1.

2-2 Application, Type "A" Kit

a. Revetments: The principal use of the Type "A" Field Fortification Kit is to make revetments; i.e. around UH-1 series helicopter positions, barracks buildings, and other applications which need "low-wall" revetment protection. A typical helicopter revetment is shown on LWL Drawing No. 050099700. (A copy of the drawing is attached to this manual as Appendix A-1.) This helicopter revetment requires one (1) Type "A" Field Fortification Kit. A typical barracks building revetment is shown on LWL Drawing No. 050099300. (A copy of this drawing is attached as Appendix A-2.) The barracks building revetment, which also includes a personnel bunker at each end of the barracks building, requires three (3) Type "A" Field Fortification Kits - three of the basic modular quantities of material as listed in Table 2-1.

WARNING

As shown on Drawing No. 05009300, the personnel bunkers embody the use of a sandbag parapet wall extension. The sandbag wall provides an approximate 6-foot ceiling height for the bunker, achieved by extending the walls upward from the 57" height (height of the Type "A" aluminum panels) with a 4-layer sandbag wall. This arrangement is safe, but after exposure over a period of time in a wet environment, the sandbags in the wall extension may deteriorate, thereby resulting in a potentially unsafe condition. For that reason, TYPE "A" BUNKERS ARE TO BE CONSIDERED AS TEMPORARY

ITEM NO.	DESCRIPTION	UNIT WEIGHT LBS.	NUMBER REQUIRED
	0.10" thick aluminum sheet panels with corrugations of 2 1/2" depth by 9" pitch:		
8N-A	57 1/2" x 81.71"	52.6	20
Half 8N-A	28 3/4" x 81.71"	26.3	6
10N-A	57 1/2" x 100.95"	65.0	12
12N-A	57 1/2" x 120.19"	77.4	8
14N-A	57 1/2" x 139.43"	89.8	14
20-A	Special: 57 1/2" x 20"	13.0	28
1-C-A	23' x 3/16" galvanized wire rope assembly		72
2-P	12' x 100' plastic sheet (roll)		1
3-P	4' x 500' plastic sheet (roll)		1

TABLE 2-1: Materials List for One (1) Type "A" Field Fortification Kit

BUNKERS, AND MUST BE RESTRICTED TO A FOUR (4) MONTH USEFUL LIFE: THE ALTERNATIVE TO THE 4-MONTH LIFE RESTRICTION IS THAT THE SANDBAG PARAPET WALL EXTENSIONS MUST BE REBUILT WITH NEW SANDBAGS AT FOUR (4)-MONTH INTERVALS.

b. Bunkers: Although the Type "A" Field Fortification Kits are intended primarily for use in making revetments, the Type "A" kits can be used to make temporary bunkers. When used to make temporary bunkers, however, the WARNING stated above must be strictly observed. A typical Type "A" temporary living/fighting bunker is shown on LWL Drawing No. 050099100. (A copy of this drawing is attached as Appendix A-3.) A typical temporary command post facility of battalion level size is shown on LWL Drawing No. 050099500. (A copy of this drawing is attached as Appendix A-4.) Three (3) Type "A" Field Fortification Kits are required to build the command post facility.

Section II. Type "B" Field Fortification Kit

2-3 Components, Type "B" Kit

The Type "B" Field Fortification Kit is, essentially, an assortment of 75 1/2" high corrugated aluminum panels and a specified number of 27-foot long galvanized wire rope segments. The assortment includes a sufficient quantity to erect a typical living/fighting bunker. The corrugated aluminum panels are a standard commercial product used in industrial applications, principally to make marine bulkhead retaining walls and highway drainage culverts. The wire rope segments, which serve to connect the aluminum panels to each other, are made from standard commercially available 7 x 19 galvanized steel wire rope of 3/16" diameter. The only significant difference in the Type "B" components and the Type "A" components is the wall panel height; Type "B" panels are 75 1/2" high whereas Type "A" are 57 1/2" high. A complete list of the components which make up a Type "B" Field Fortification Kit is given in Table No. 2-2.

2-4 Application, Type "B" Kit

a. Bunkers: The principal use of the Type "B" Field Fortification Kit is to make bunkers; i.e. living/fighting bunkers, command post bunkers, bunkers for perimeter guard positions around base encampments, personnel bunkers at the ends of barracks buildings, and many others. A typical living/fighting bunker is shown on LWL Drawing No. 050099200. (A copy of the drawing is attached to this manual as Appendix B-1.) A typical Battalion TOC arrangement is shown on LWL Drawing No. 050099600. (A copy of this drawing is attached hereto as Appendix B-2.) The Battalion TOC arrangement, Appendix B-2, requires four (4) Type "B" Field Fortification Kits - four of the basic modular quantities of material as listed in Table 2-2.

b. Revetments: Type "B" Field Fortification Kits can also be used to make revetments; i.e. around barracks buildings, around equipment storage positions, and other applications which are not restricted to "low-wall" revetments. A typical barracks building revetment arrangement, including a personnel bunker at each end of the building, is shown on LWL Drawing 050099400. (A copy of this drawing is attached hereto as Appendix B-3.)

ITEM NO.	DESCRIPTION	UNIT WEIGHT LBS.	NUMBER REQUIRED
	0.10" thick aluminum sheet panels with corrugations of 2 1/2" depth by 9" pitch, specific sizes as follow:		
8N-A	57 1/2" x 82" standard panel	53	2
8N-B	75 1/2" x 82" standard panel	66	6
10N-A	57 1/2" x 101" standard panel	65	4
10N-B	75 1/2" x 101" standard panel	82	6
12N-A	57 1/2" x 120" standard panel	78	2
12N-B	75 1/2" x 120" standard panel	98	2
14-B	75 1/2 x 140" standard panel	115	5
20-A	Special 57 1/2" x 20" panel (20" dim. is parallel to the corrugations)	13	10
20-B	Special 75 1/2" x 20" panel (20" dim. is parallel to the corrugations)	16	20
42-A	Special 57 1/2" x 42" panel (42" dim. is parallel to the corrugation)	27	8
42-B	Special 75 1/2" x 42" panel (42" dim. is parallel to the corrugation)	35	8
Half 8N-A	Special 28 3/4" x 82" panel (72" dim. is parallel to the corrugation)	26	4
1-C-A	25-ft x 3/16" galv. wire rope assembly	1	50
1-C-B	30-ft x 3/16" galv. wire rope assembly	1	20
2-P	12-ft x 100-ft plastic sheet (roll)	10	1
3-P	4-ft x 500-ft plastic sheet (roll)	25	1

TABLE 2-2: Materials List for One (1) Type "B" Field Fortification Kit

CHAPTER 3

FABRICATION INSTRUCTIONS

Section I. Safety Precautions

3-1 Safety Mindedness

Successful application of the Field Fortification Kit requires a well exercised measure of safety mindedness. When the Field Fortification Kit is used to make a bunker, whether it is to be Type A or Type B, the bunker must be "planned right" and "put up right"; otherwise, it cannot be considered safe. This is due in large part to the unusually high roof loads imposed by the sandbagged roof, to the fact that the roof is not physically tied to the walls, and to the fact that the load bearing walls do not have "prepared" foundations. It is especially important, therefore, that the users of the Field Fortification Kits understand and apply the safety procedures described in Paragraph 3-2 below.

3-2 Safety Procedures

a. Use hand gloves at all times while handling the corrugated aluminum panels.

b. Apply the Appropriate "Type" of Field Fortification Kit: First of all, if a bunker is to be built for a life expectancy longer than four (4) months, USE TYPE "B" FIELD FORTIFICATION KITS - THE KITS WITH THE HIGH WALL PANELS. The alternative is to institute an operational plan to disassemble the roof and parapet wall extensions at least once each four (4) months, and to renew the parapet wall extensions with new sandbags. When building the sandbag parapet wall extensions, and when renewing them, it is imperative that the sandbags be carefully and skillfully placed so as to provide a uniformly solid bearing wall. The purpose of renewing the sandbags each four (4) months is to insure that the roof is not being supported by partially deteriorated sandbags.

c. Build on Fairly Level and Uniformly Textured Terrain: The bunker (and revetment) walls must be erected on fairly level and uniformly textured terrain so that the bunker (or revetment) wall footing area does not sink significantly more under one side of the wall than under the other, and the ground footing area under one bearing wall does not sink significantly more than the ground footing area under the opposite load bearing wall.

d. Provide Lateral Support to the Terminal Ends of All Load-Bearing Walls: In those locations where the bunker load-bearing walls would terminate as a wall end without lateral support, i.e., at an entry way, a right angle turn, with a

wall panel bay must be used. For example, a wall panel bay must be installed at eacn side of the entry way, meeting the bunker bearing wall at right angles on each side of the entry way.

e. Limit the Width of Openings in Load-Bearing Walls to the Minimum Tolerable Value: Each opening in the bearing wall is bridged by a lintel on top of the bearing wall. The lintel transmits the load from the unsupported part of the roof (the length of roof which is directly over the wall opening) into a short length of the bearing wall at each side of the opening. This, in effect, overloads the bearing wall on each side of the wall opening; the amount of overload increasing as the width of wall increases. It is, therefore, important that the width of the window openings and the passage way openings be kept to a minimum. The openings should be limited to approximately 24 inches for windows and approximately 36 inches for passage ways.

f. Limit the Maximum Roof Span to 82": The inside clear span between load-bearing walls must not exceed 82" (82" is the length of one 8N panel, Table 2-1 or 2-2).

g. Place the Roof Sheets Properly: The roof sheets must be long enough to extend completely across both load-bearing walls, and must be accurately emplaced so that they will completely cover both sandbag capped bearing walls. Otherwise the roof loading will not be uniformly distributed onto the sandbag capped walls.

h. Do Not Neglect to Properly Emplace the Plastic Closure Sheets Over the Panel Bay Wall Connections: Where the corrugated aluminum panels are joined together in making wall panel bays, there are openings in the joints due to a misfit of the corrugations in adjacent panels. If these joints are not lined with the prescribed "dirt stop liners", the fill material will gradually seep out of the wall panel bays. The seepage will create a safety hazard if left unchecked. Refer to Paragraph 3-4 below.

i. Fasten the Wall Panel Connections Securely: The wall panel bays are fabricated by tying the corrugated aluminum panels to each other with wire rope cable segments. It is important that these "laced" joints be made snugly, and that the free ends of the cables be tied off securely. Refer to Paragraph 3-3 below.

j. Do Not Neglect to Apply the Plastic Cover Sheet Under the Top Layer of Sandbags on the Bunker Roof: As described in Paragraph 3-9 below, the roof is sandbagged with several layers of sandbags. A plastic sheet must be installed under the top layer of sandbags. This plastic sheet serves a very important purpose; it keeps the basic sandbag roof cover dry, which is required in order to assure adequate ballistic protection against 81mm mortar fire. If the basic sandbag cover (the bottom 3 layers) is wet, a direct hit by 81mm mortar fire will most likely cause significant damage to the roof structure.

Section II. Assembly Procedures

3-3 Walls, Type "A" and Type "B"

Refer to Figures 3-1 thru 3-5 for illustrations of the wall assembly procedures. Note, from Figure 1, that there are four different conditions of wall assembly connections encountered in building any bunker or revetment. These four connections, and the suggested method for making each connection with a wire rope cable assembly are described in the paragraphs following:

a. Corner Panel Connection (Refer to Figure 3-2): To make the corner panel connection, start by loop-fastening the wire rope to the top of one panel. Then lace the two panels together as shown in Figures 3-2. Tie-off the free end of the cable, which projects from the bottom hole in the panel, in any expedient but secure manner.

b. Wing-Tee Panel Connection (Refer to Figure 3-3): The wing-tee panel connection provides the connection between two abutting wall sections which come together at right angles. The wing-tee connection joins three panels. To make this joint, begin by loop-fastening the cable assembly to the top of one of the panels; then connect the three panels by lacing the cable thru them as shown in Figure 3-3. Then tie-off the free end of the cable, which extends from the bottom hole, in an expedient but secure manner.

c. Spliced-Tee Panel Connection (Refer to Figure 3-4): The spliced-tee connection between two wall sections joined end-to-end with a common cross panel (the 20" panel). The spliced-tee joins two end-lapped panels to a 20" cross panel. Refer to Figure 3-4a. To make the spliced-tee, begin by loop-fastening the cable assembly into a hole at the top of one of the panels. Then lace the three panels together as shown in Figure 3-4. Tie-off the free end of the cable.

d. Straight-Tee Panel Connection (Pefer to Figure 3-5): The straight-tee joins the interior panel of one wall section to the interior panel of an abutting wall section - connecting one interior wall panel perpendicular to another. To make the straight-tee begin by loop-fastening the cable into the top hole of one of the panels. Then lace the two panels together as shown in Figure 3-5, and tie-off the free end of the cable.

3-4 Plastic "Dirt-Stop" Liners for the Wall Panel Connections

Make "dirt-stop" liners by cutting 8-foot long strips of plastic sheet from the 4-foot wide roll which was furnished with the kit. Drape one "dirt-stop" liner inside the wall sections, one at each panel connection. The plastic liner prevents loss of fill material thru the openings at the panel connections. Exercise care as necessary to assure that the liner is not pushed aside by the fill dirt during the wall section filling operation.

3-5 Fill Material for the Wall Sections:

Fill each wall section (panel bay) with any available earth material. If a front end loader is used to fill the walls, some of the earth materials will be spilled around the wall sections. Shovel the spilled material into the wall sections by hand. Tamp the dirt at regular intervals during the filling operations. Assure that the dirt-stop liners remain in place, and that they prevent dirt seepage from the wall sections. Fill and pack the walls to a "level-full" condition.

3-6 Sandbag Cap for the Wall Sections:

a. For Revetments, Types "A" and "B": Place a 3-foot wide strip of plastic sheet over the filled wall, positioning it symmetrically on the wall. Then place one layer of sandbags on top of the earth-filled wall, completely covering the plastic sheet. The revetment will then be complete. Refer to Figures 3-8, 3-9, and 3-10.

b. For Type "B" Bunkers: Place one layer of sandbags on top of the dirt-filled wall. This layer of sandbags serves as the support bed for the roof cover panels, Figure 3-11.

c. For Type "A" Bunkers: The sandbag cap for Type "A" bunkers consists of sandbag parapet wall extensions. Refer to Figures 3-6 and 3-7. To make the sandbag parapet wall extension, place four (4) layers of sandbags on top of the dirt-filled wall sections, making each layer extend the full width of the wall top ledge. This extends the wall height to approximately six feet, and provides a sandbag bed support for the roof panels. Provide firing ports (or windows) by leaving void spaces, approximately 18" wide, at the desired locations in the sandbag wall extension. Refer to Figure 3-6.

WARNING

When building the sandbag parapet wall extensions it is imperative that the sandbags be carefully and skillfully placed so as to provide a uniformly solid load-bearing wall. The top of this wall extension provides the sandbag bed support surface which transmits the heavy roof loads into the walls.

3-7 Window Lintels (Bunkers Only):

Place one lintel (half 3N panel, Table 2-1) symmetrically over each window opening, the corrugations of the lintel running parallel to the wall. Refer to Figures 3-6 and 3-7. Lintels are not required over window openings in non-load-bearing walls; walls running parallel to the roof panel corrugations are non-load-bearing.

3-8 Roof Panels (Bunkers Only):

Place the roof panels symmetrically over the span between the two opposite load-bearing walls. Position the roof panels in such manner that the sandbag capped walls are completely covered by the roof panels. Overlap adjacent roof panels by at least one corrugation.

3-9 Sandbag Cover on the Roof (Bunkers Only):

a. Basic 3-Layer Cover: Place three layers of sandbags over the entire roof surface.

b. Plastic Sheet for Weatherproofing: Place a plastic cover sheet over the 3-layer sandbag arrangement, completely covering all sandbags.

WARNING

Resist the temptation to dispense with this plastic cover sheet. The plastic cover sheet is imperative as concerns safety of the bunke. occupants in the event of mortar attack. It will keep the basic 3-layer sandbag cover dry; wet sandbags will not provide protection against transmission of the mortar round blast forces. The plastic cover sheet will also prevent deterioration and decay of the basic sandbag cover.

c. Top Layer of Sandbags: Place a layer of sandbags over the plastic cover sheet, completely covering the plastic cover sheet. The Type "B" bunker is now complete. Refer to Figure No. 3-11.

CHAPTER 4

MAINTENANCE INSTRUCTIONS

Section I. Revetments

Inspect the sandbag cap and plastic cover periodically for deterioration due to weathering or external damage. When significant deterioration is detected, or damage is incurred, remove the affected parts of the sandbag cap and/or plastic sheet and replace with new materials. Inspect the walls from time to time for dirt seepage at the panel connections. If seepage is detected, pack the seepage holes (defects in the plastic liner) with any available material as necessary to stop the seepage. Very little maintenance is anticipated.

Section II. Bunkers

a. All Bunkers: Inspect the top layer of sandbags on the roof and the plastic cover sheet (by spot check) from time to time for deterioration due to weathering and/or external damage. When significantly deteriorated sandbags or plastic cover are detected, remove and replace the affected parts with new materials. When and if direct hits by mortar fire are incurred, repair the hole (damaged sandbags and plastic cover) by removal of the damaged materials and replacement with new materials. Also check the bunker walls occasionally for dirt seepage at the panel connections. If seepage is detected, pack the seepage holes (defects in the plastic liner) with any available material to stop the dirt loss from the wall.

c. Type "A" Bunkers Only: Inspect the sandbag parapet wall extension from time-to-time for deteriorated sandbags. When deteriorated sandbags are discovered, disassemble the roof and sandbag parapet wall extension. Rebuild with new materials.

CHAPTER 5

DISASSEMBLY, REASSEMBLY, AND RE-USE

Section I. Disassembly

The field fortifications, whether bunkers or revetments, can be disassembled and stored for re-use. Disassembly procedures are as follows: Remove the sandbags from the roof and retrieve and store the aluminum roof panels. Remove the sandbag wall extension from the aluminum panel bay walls. With a cable cutter or bolt cutter, beginning at the bottom of each wall panel connection, cut the laced cable until the panels are free of each other. Retrieve the panels and store them for re-use. The procedures for disassembly of the revetment walls are the same as for the bunker walls.

Section II. Reassembly and Re-use

The disassembled field fortification materials can be re-used to build bunkers and revetments. New wire rope cable assemblies will be required. The procedures for reassembly are the same as for the initial assembly.

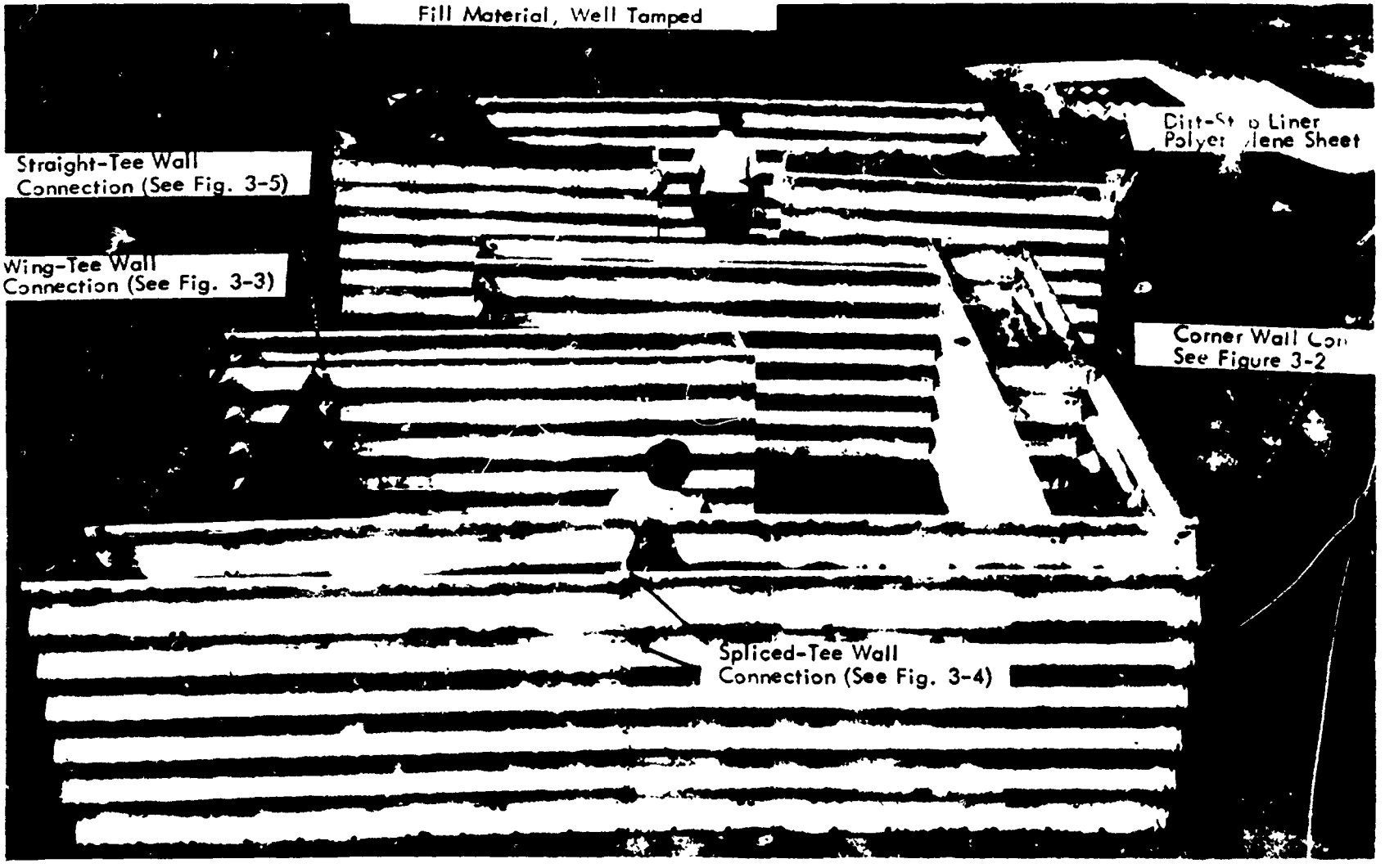


Figure No. 3-1: Typical Panel Bay Layout, Field Fortification Kit Application

Figure No. 3-2: Corner Panel Connection
Field Fortification Kit Assembly

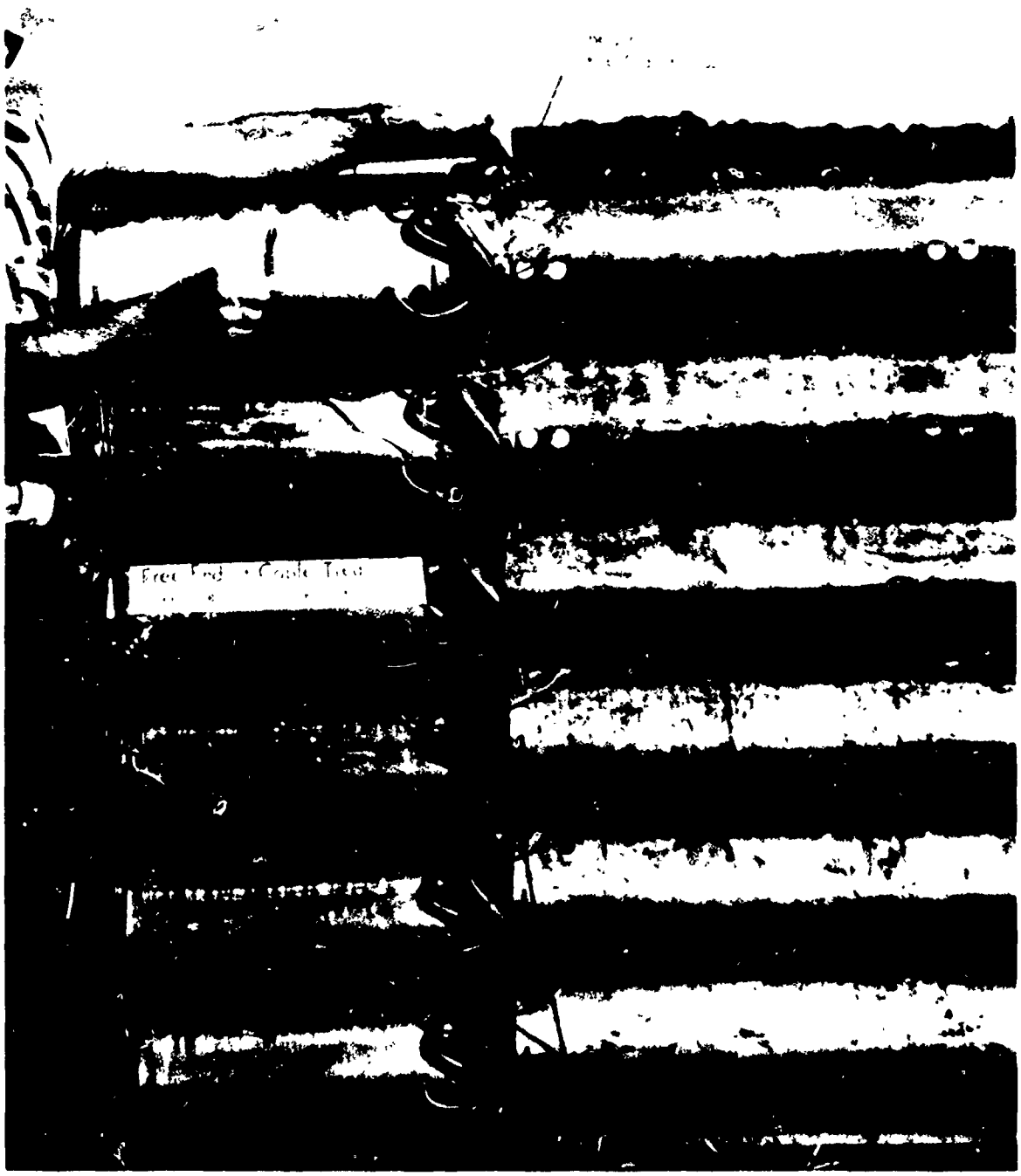


Figure No. 3-3: Wing-Tee Wall Connection,
Field Fortification Kit Assembly

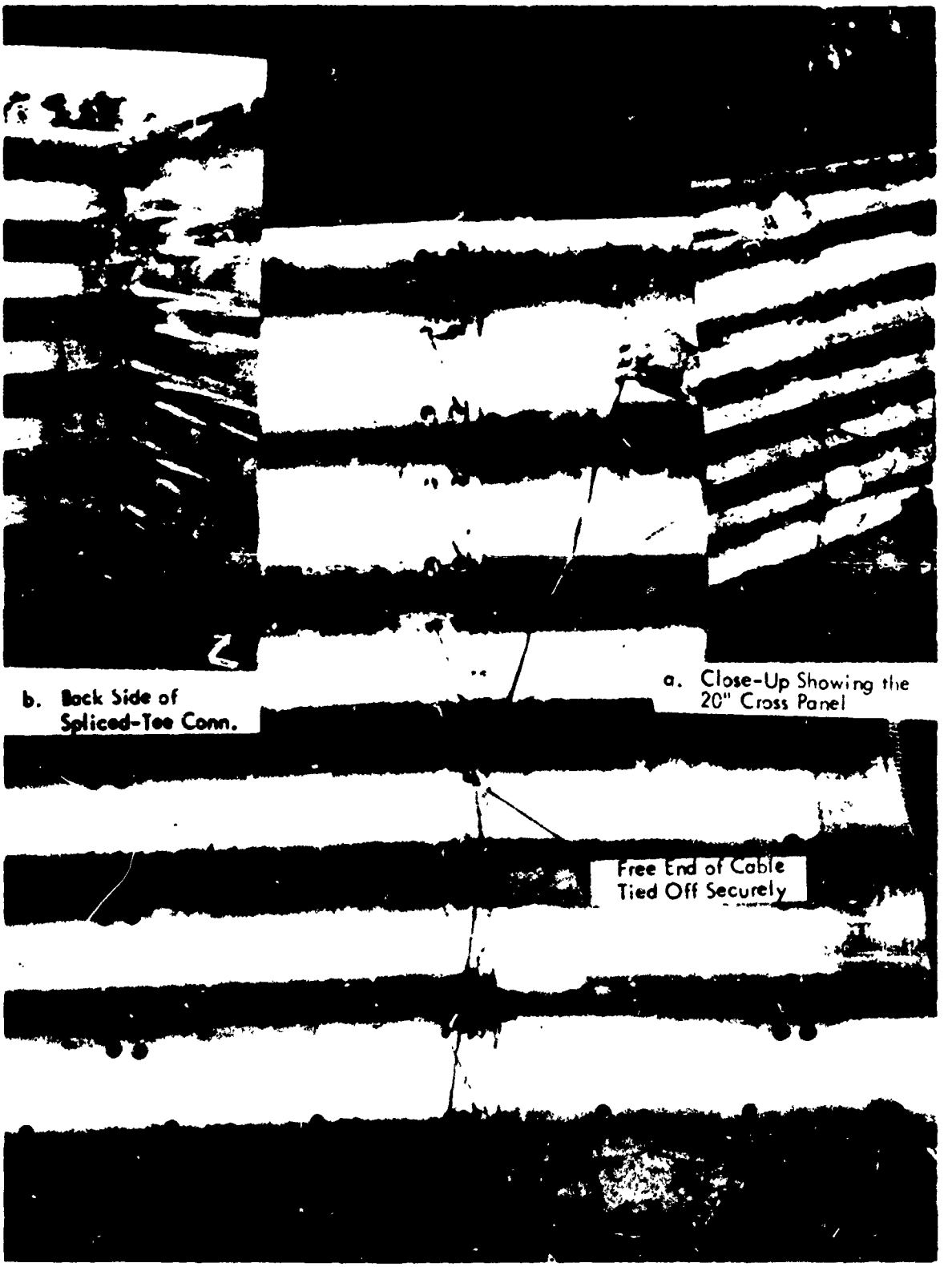


Figure No. 3-4: Spliced-Tee Wall Panel Connection,
Field Fortification Kit Assembly

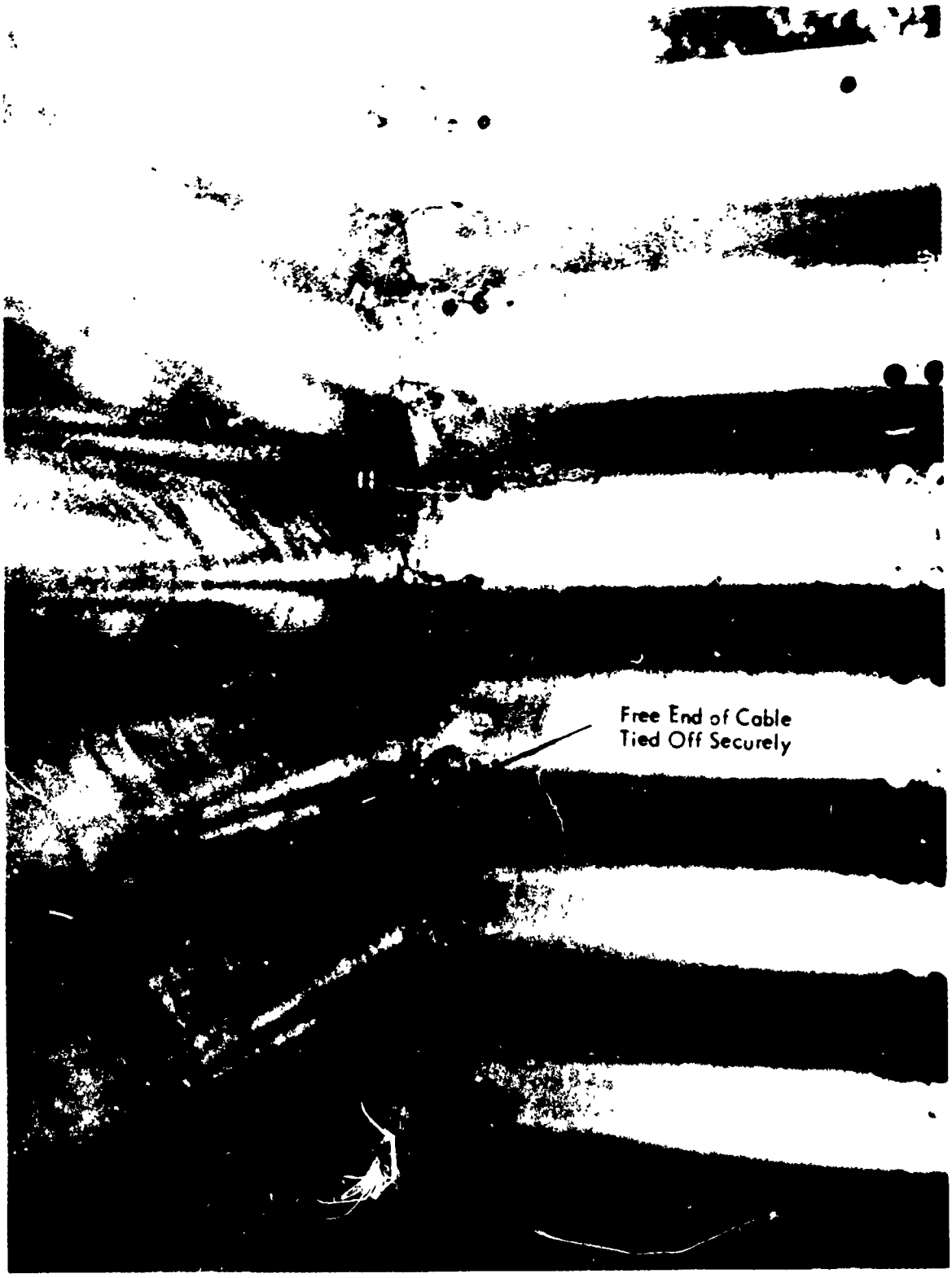


Figure No. 3-5: Straight-Tee Wall Panel Connection,
Field Fortification Kit Assembly

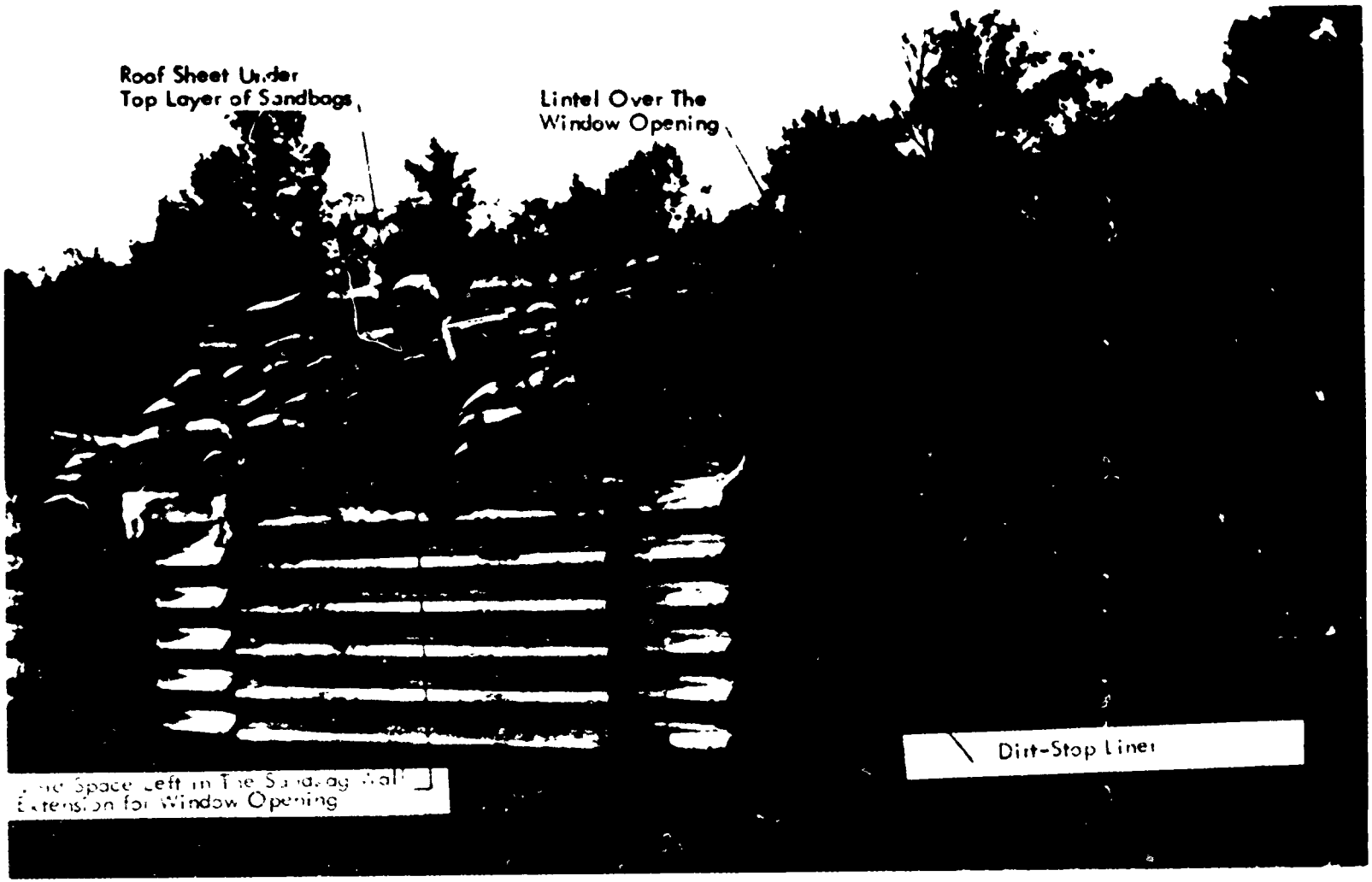


Figure No. 3-6: Typical Field Fortification Kit, Bunker Application, End View

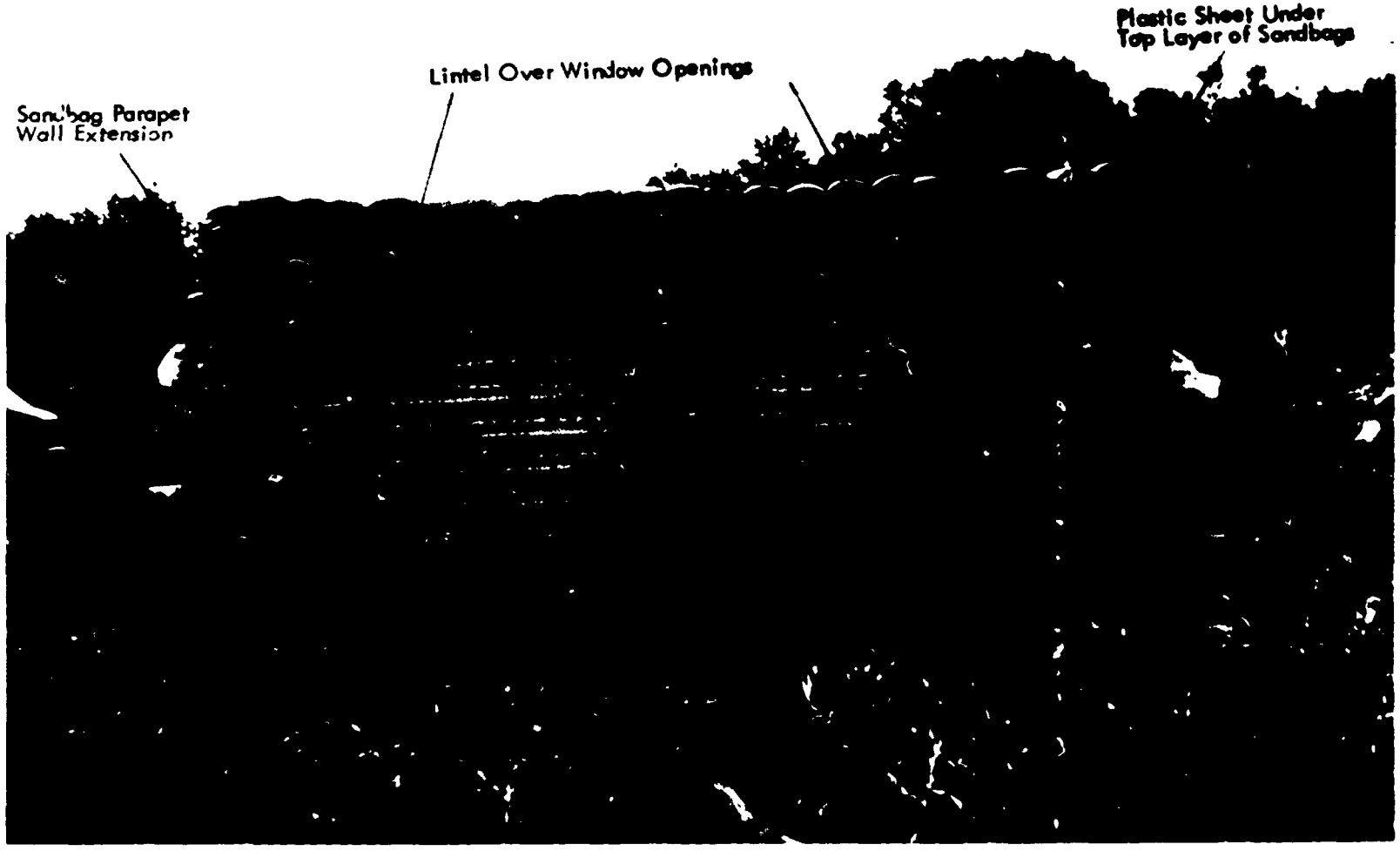


Figure No. 3-7: Typical Field Fortification Kit,
Bunker Application, Side View

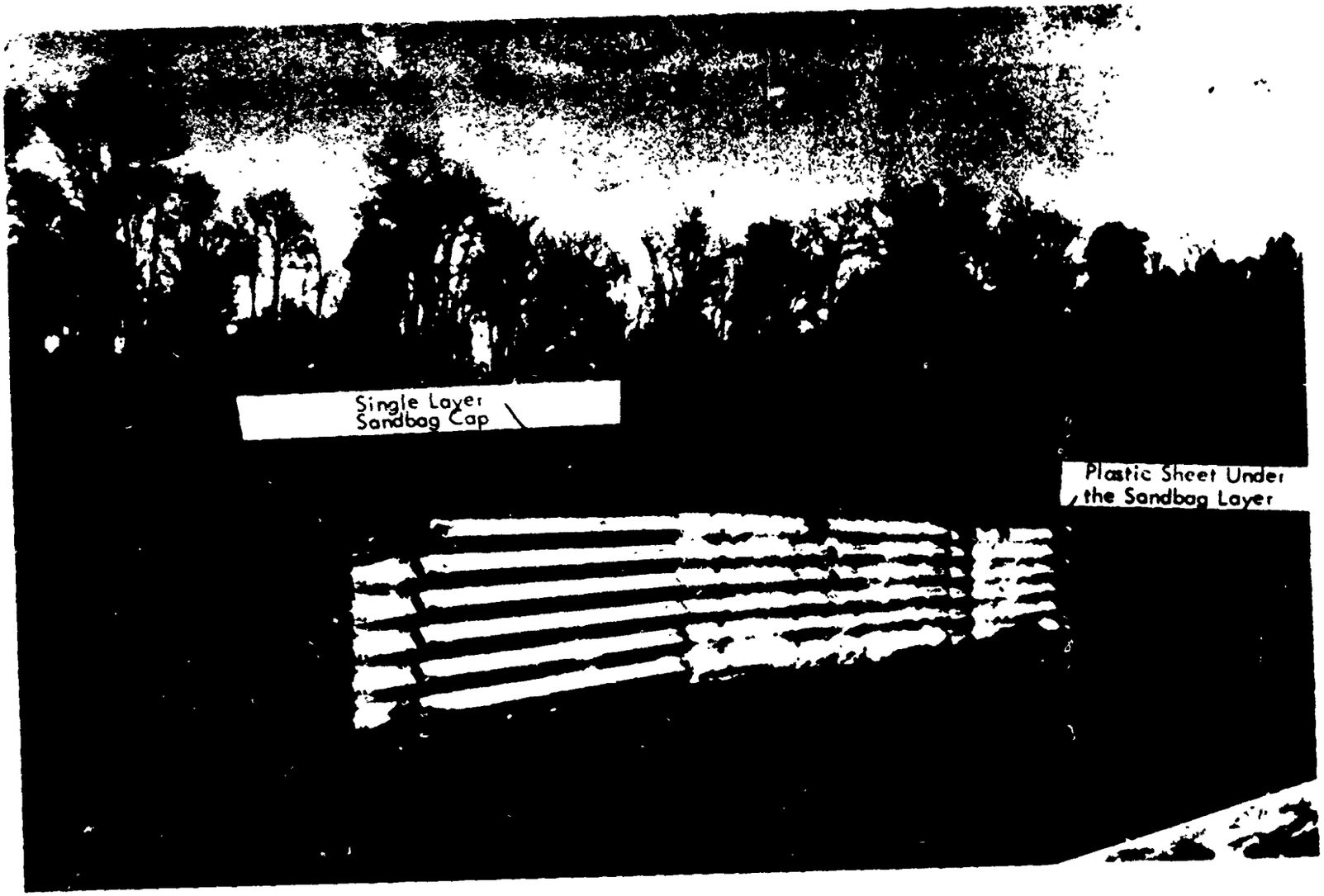


Figure No. 3-8: Typical Section of Revetment Wall, Inside View, Field Fortification Kit Application, Type "A"

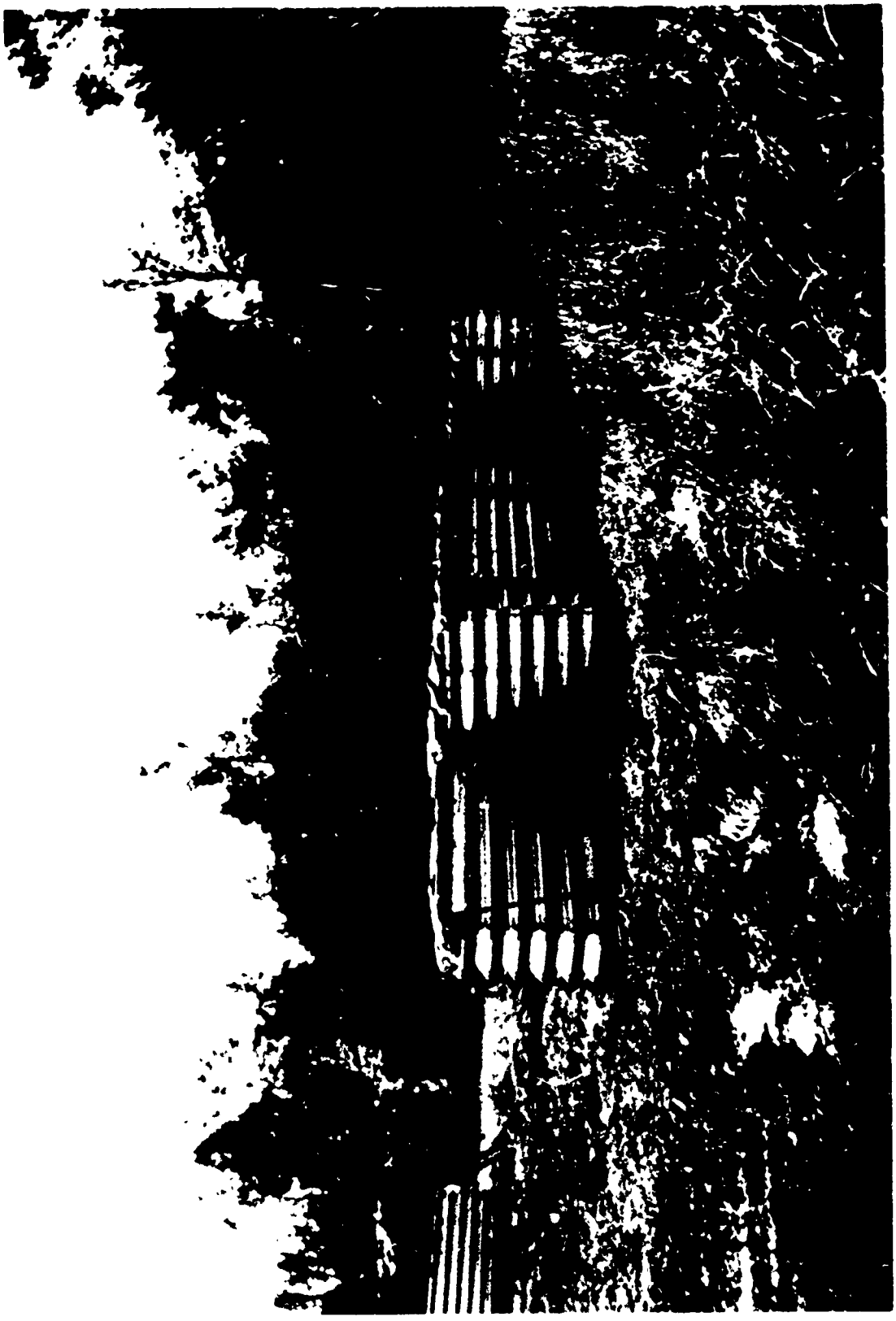


Figure No. 3-9: Typical Section of Revetment Wall, Outside View, Field Fortification Kit Application, Type "A"

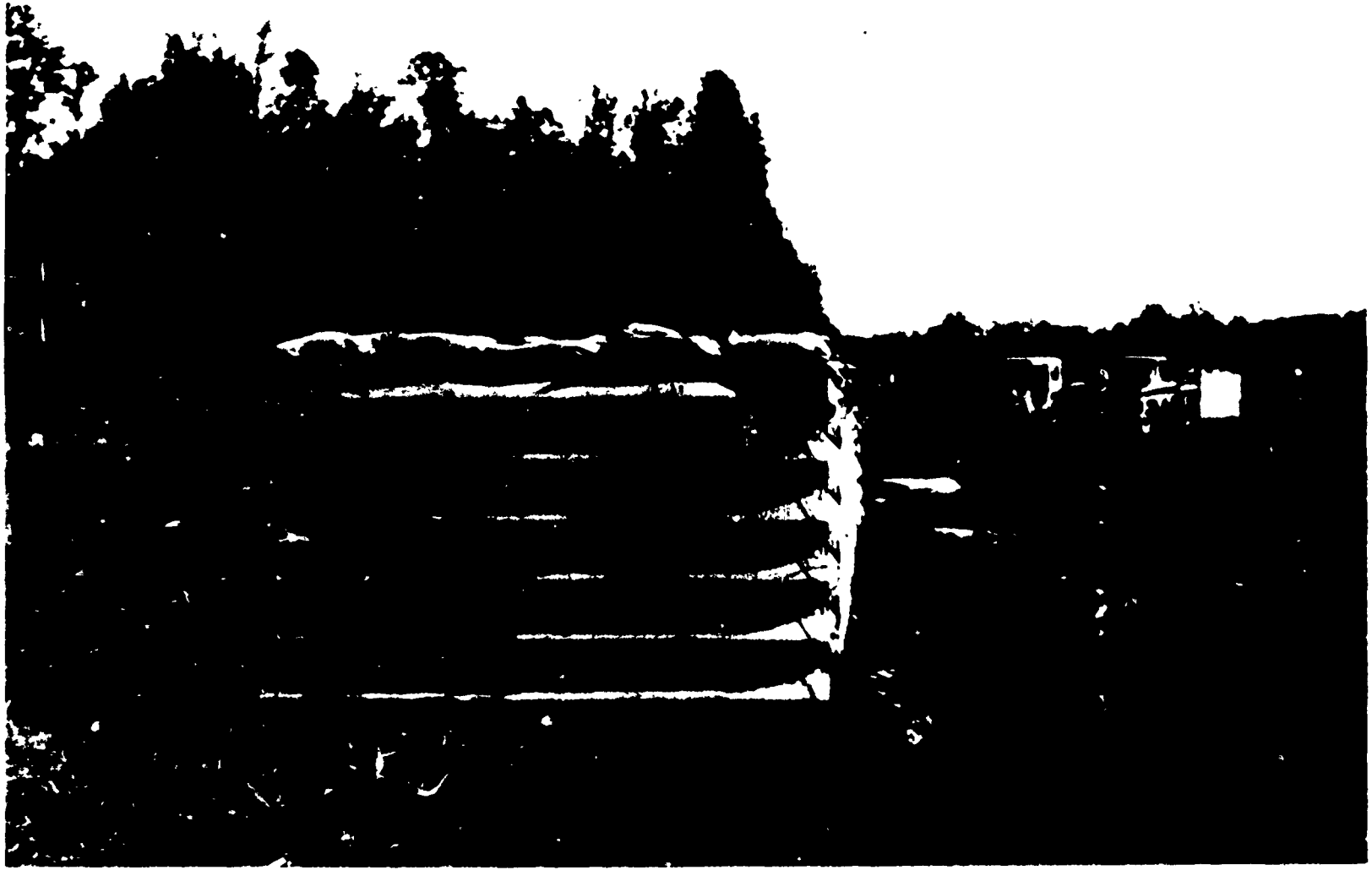


Figure No. 3-10: Typical Section of Revetment Wall, End View Showing Pilaster Bay, Type "A"

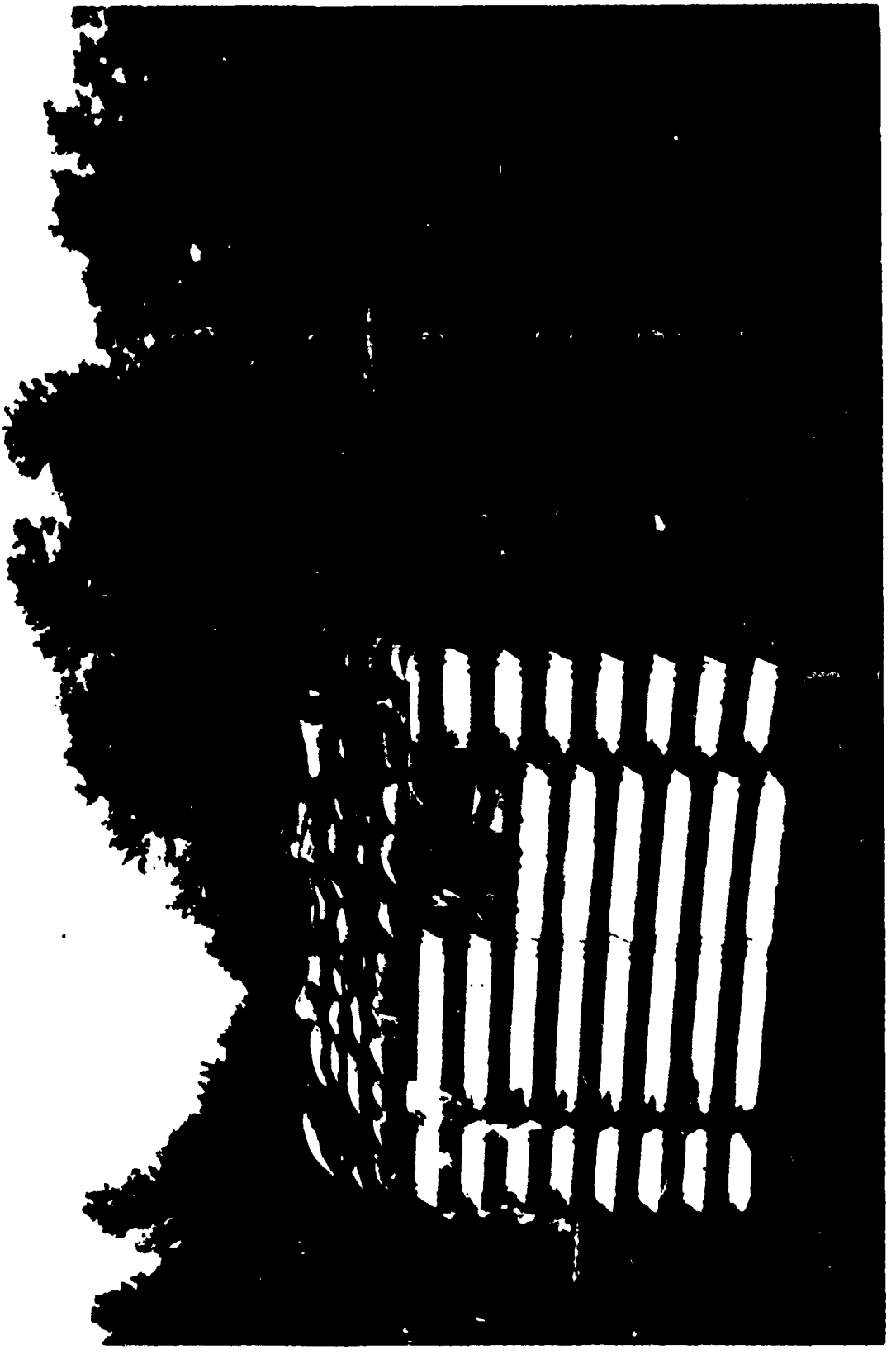
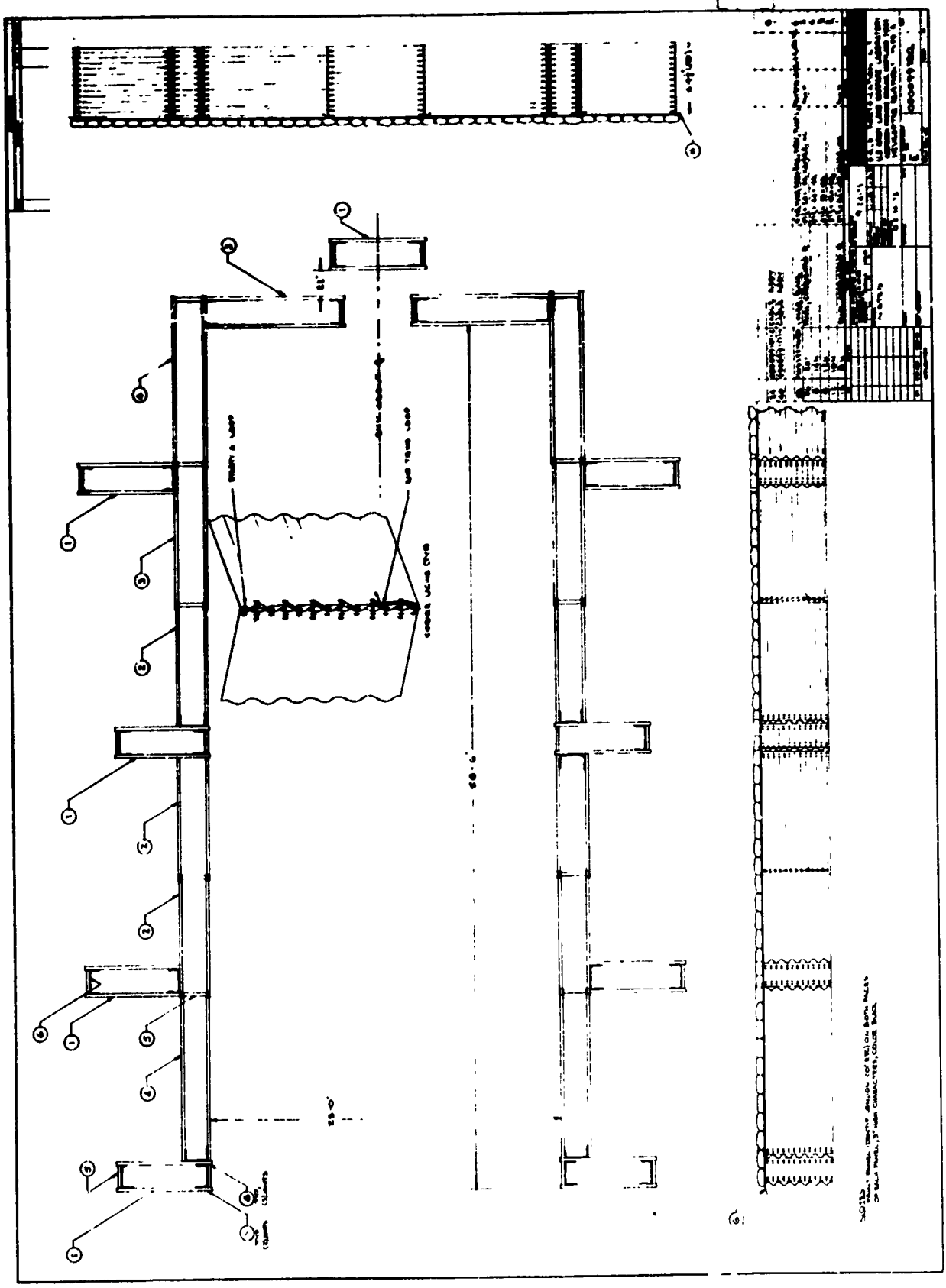
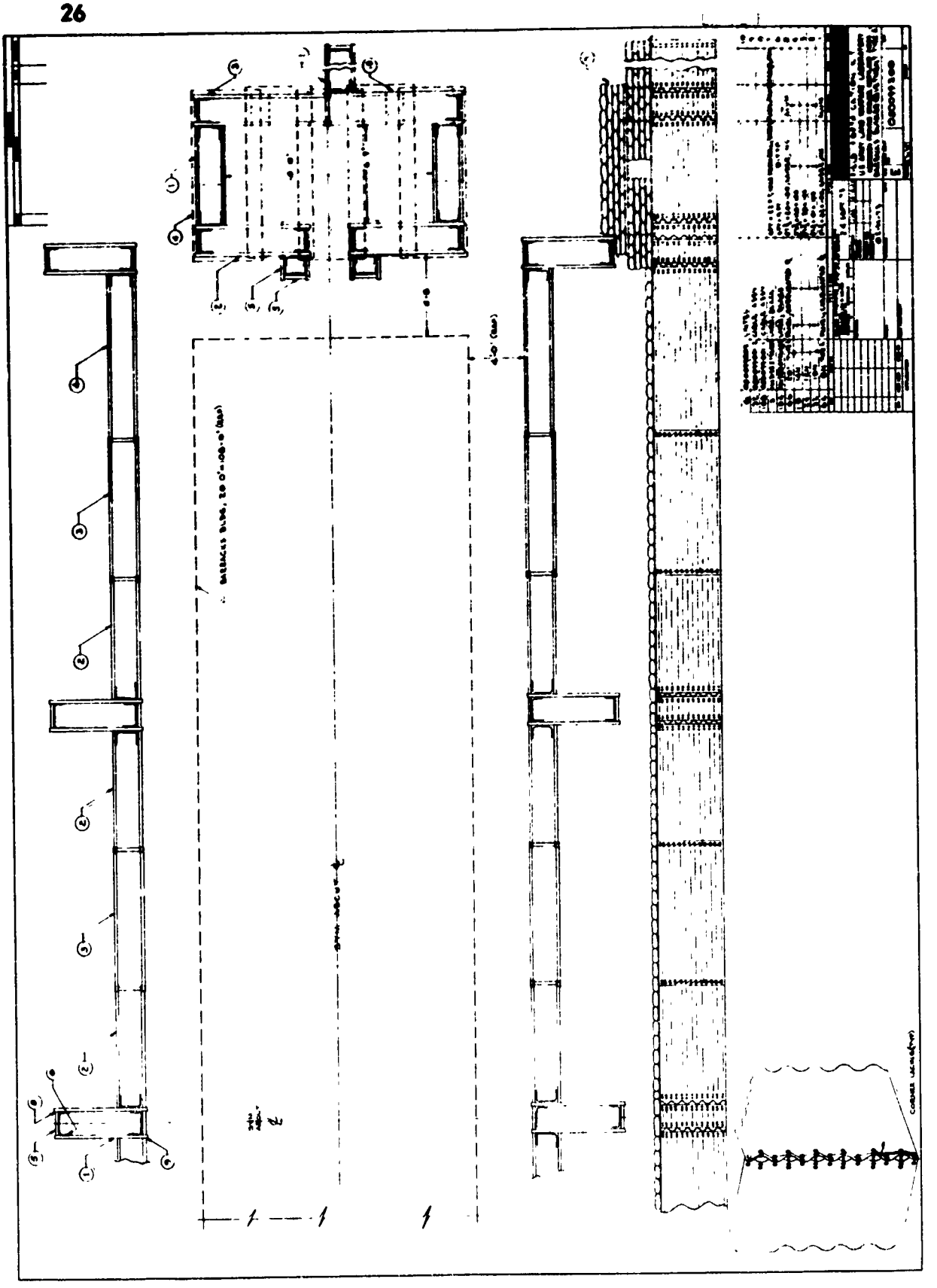


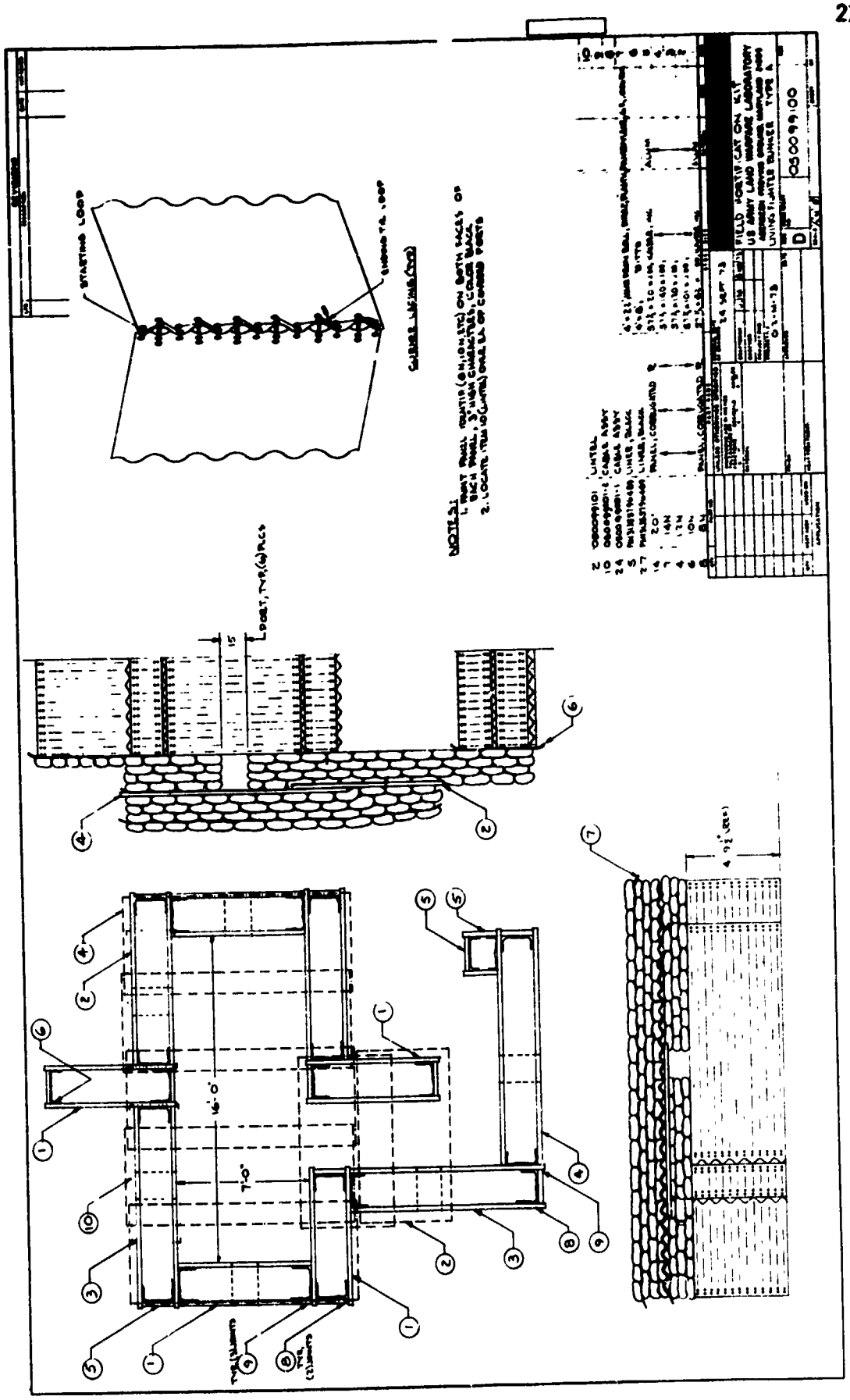
Figure No. 3-11: Typical Living/Fighting Bunker, Type "B" After Multiple Direct Hits by 81mm Mortar Rounds



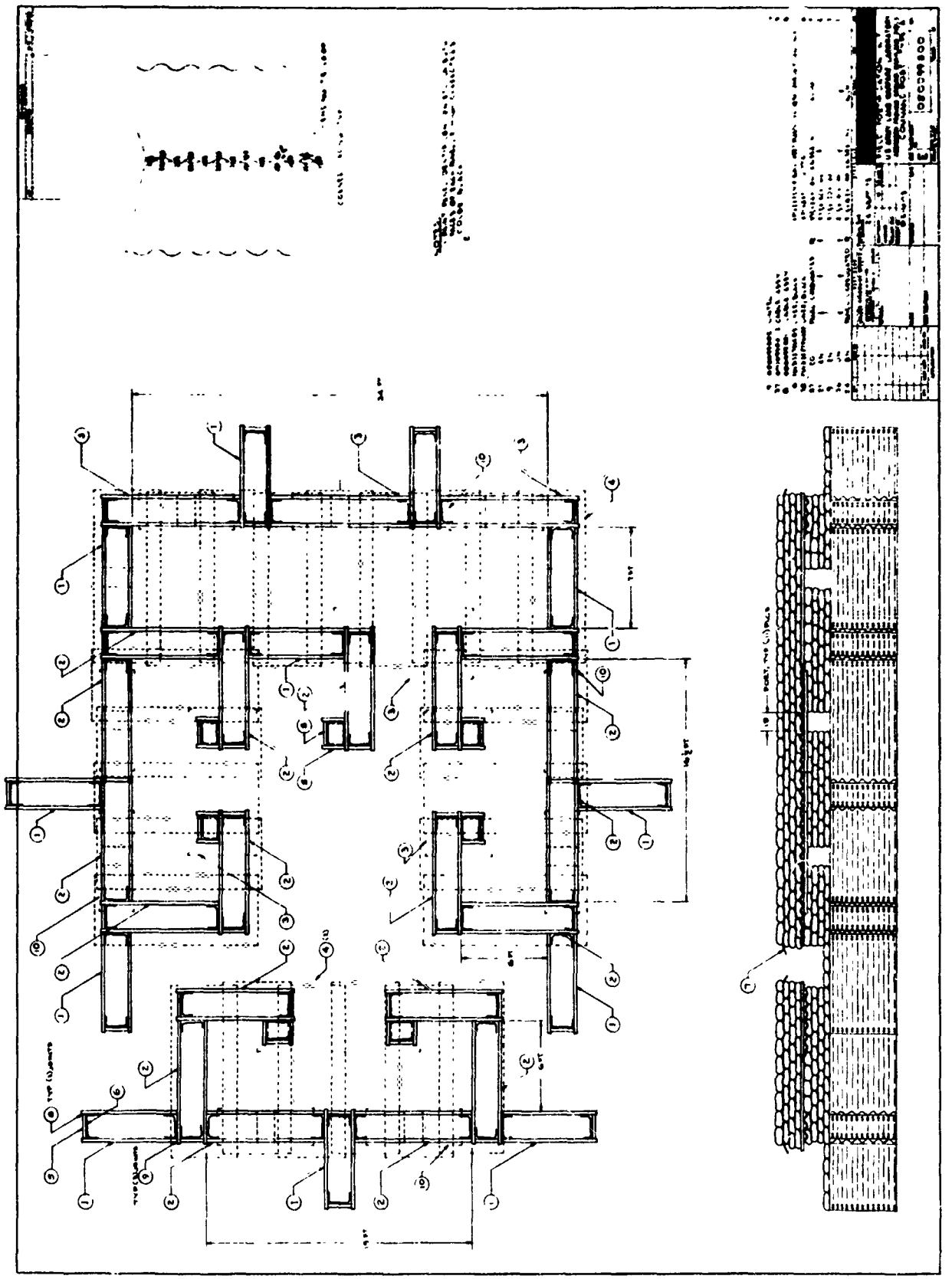
APPENDIX A-1: LWL Drawing 050099700; Type "A" Kit,
Typical Helicopter Revetment



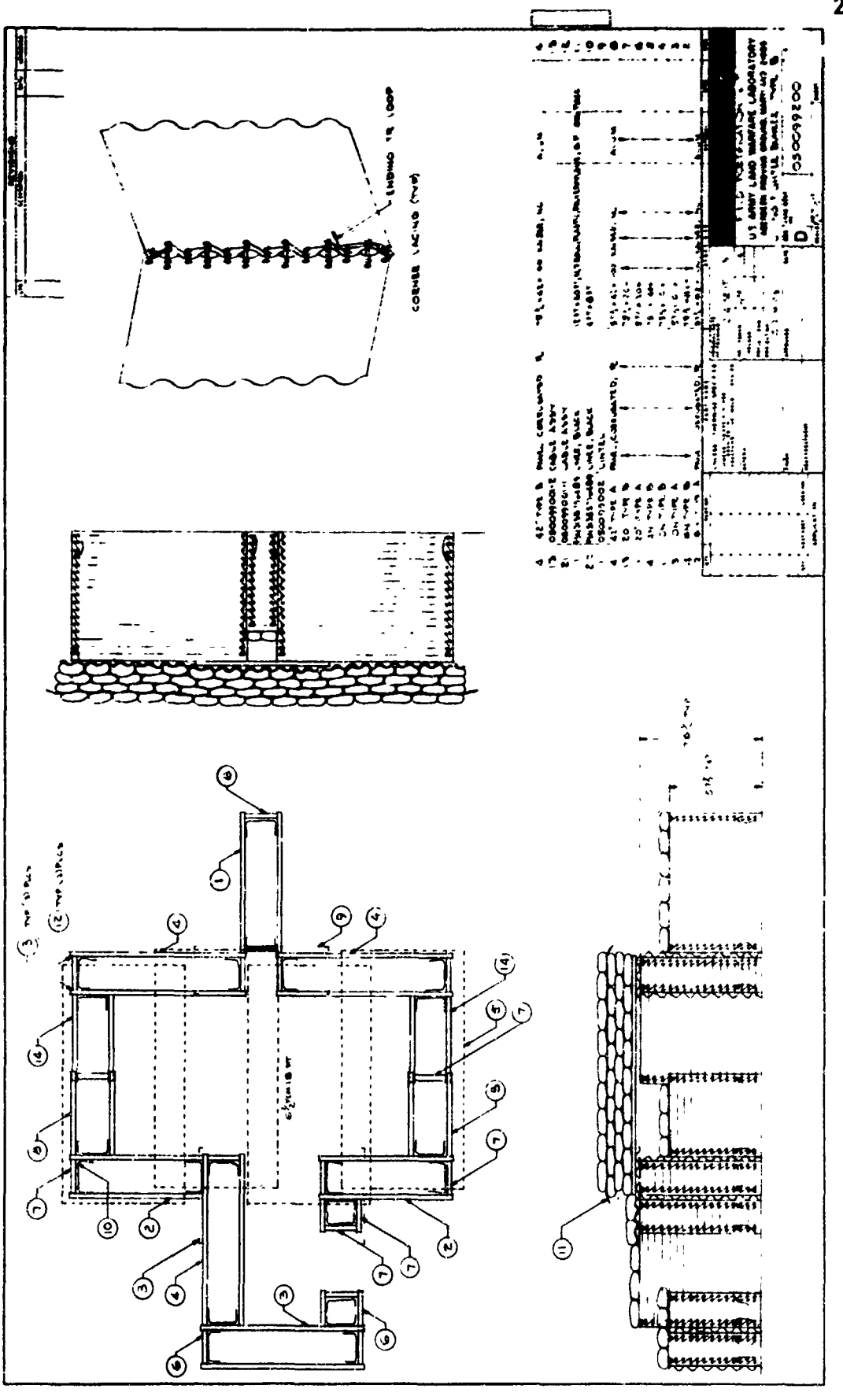
APPENDIX A-2: LWL Drawing 050099300; Type "A" Kit,
Typical Barracks Revetment



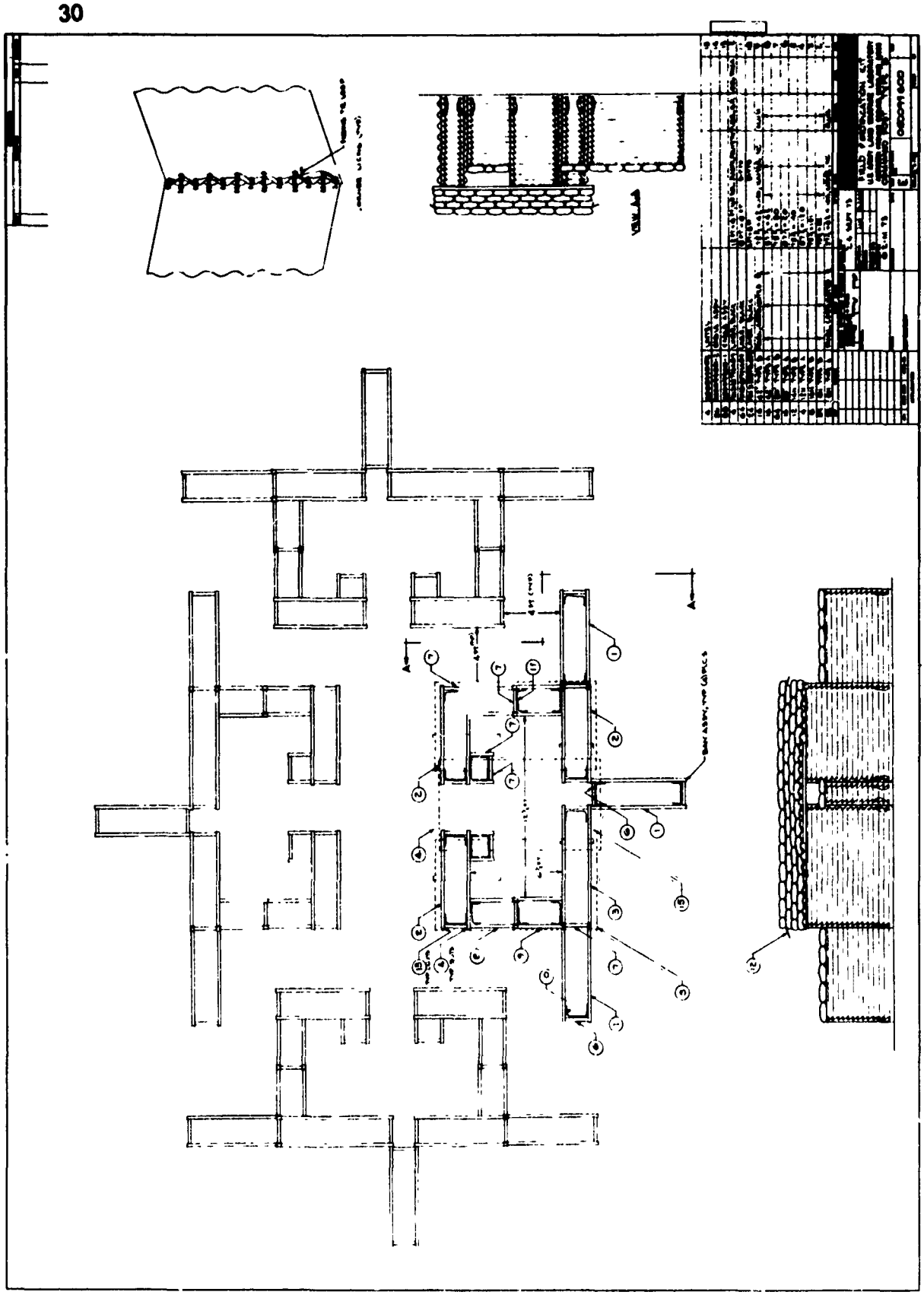
APPENDIX A-3: LWL Drawing 0500991OO; Type "A" Kit,
Typical Living/Fighting Bunker



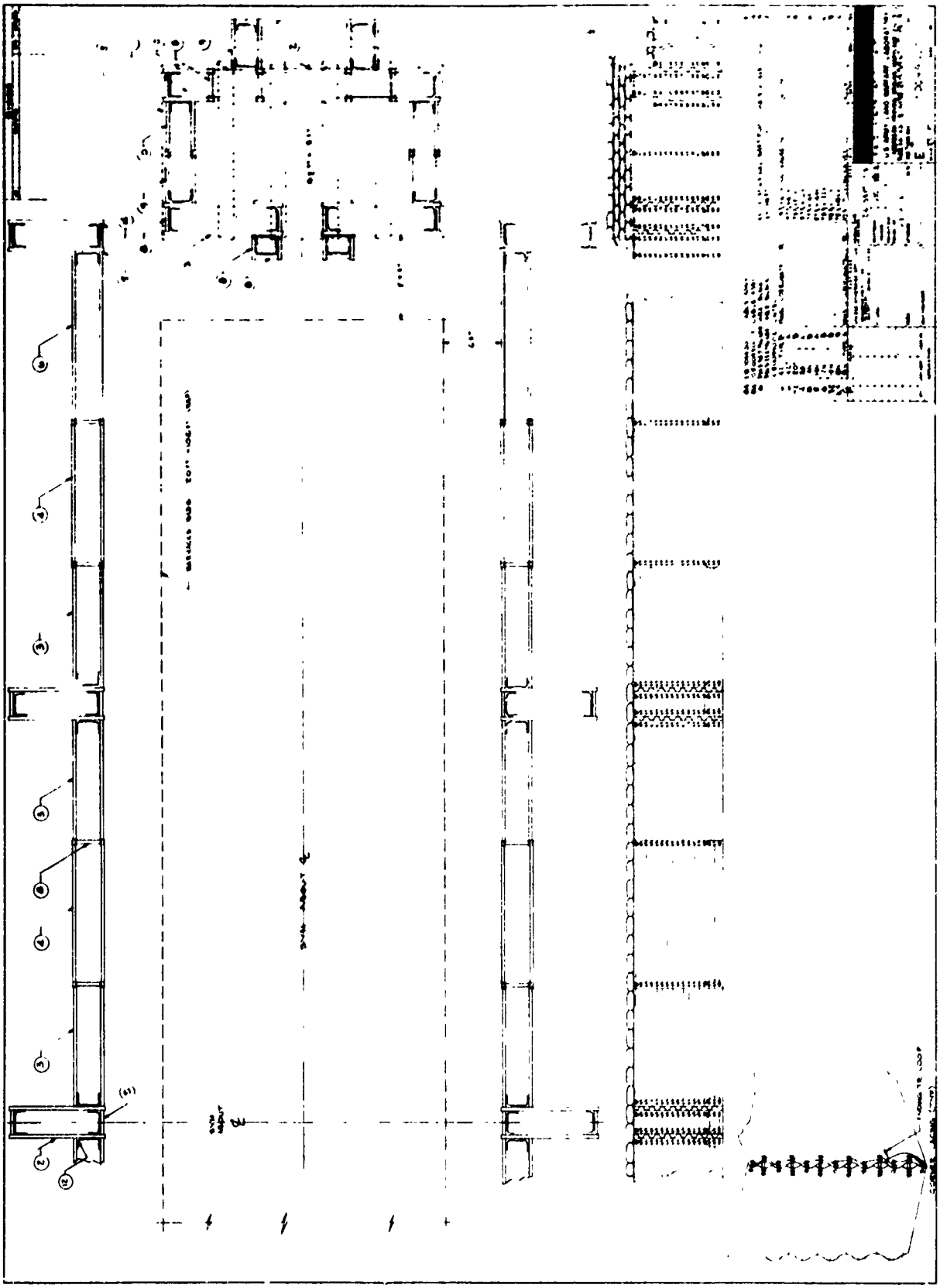
APPENDIX A-4: LWL Drawing 050099500; Type "A" Kit,
Typical Command Post



APPENDIX B-1: LWL Drawing 050099200; Type "B" Kit,
Typical Living/Fighting Bunker



APPENDIX B-2: LWL Drawing 050099600; Type "B" Kit, Typical Command Post



APPENDIX B-3: LWL Drawing 050099400; Type "B" Kit,
Typical Barracks Revetment